Materials
in Design Engineering

Formerly Materials & Methods

MATERIALS SELECTOR

1959-60 REFERENCE ISSUE

Data Section
Directory Section

Metals • Nonmetallics • Forms • Finishes • Joining and Fastening

1959-60 REFERENCE ISSUE

This third annual issue of the Materials Selector is similar to but more extensive than last year's issue. It contains 40 new pages of data, and the data published last year have been revised, in cooperation with sharp-eyed readers, to reduce or eliminate errors. In addition, the Directory has been expanded by 10% and brought up to date.

Like last year's issue, this Materials Selector consists of two major features: a Data Section and a Directory Section. Each major section is subdivided to make it as useful as possible. Contents of the entire issue are listed on these two pages; in addition, a more detailed contents page appears at the beginning of most subsections. All subsections are described briefly on the facing page and can be readily located by means of the small edge index tabs.

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DATA SECTION

The Data Section consists of ei parts. It contains extensive data the properties of virtually all im tant engineering materials (inc ing finishes and coatings), forms in which they are availa and the methods by which they be joined.

DIRECTORY SECTION

The Directory Section, consisting two parts, contains the names the leading suppliers of engineeri materials and their forms a shapes. A full explanation of organization and use of the Dir tory is given on page 466.

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Comparisons of Materials 11

Based on specific end service requirements

Tables comparing the important engineering materials with respect to a particular property (e.g., tensile strength). The major part of this section is a series of data sheets in which materials are ranked in descending order for various properties. In most cases, the materials are ranked by their average properties, the approximate range also being given. In some cases the form, temper, heat treatment or other condition of the material is given, particularly where such conditions markedly affect the value. More details on materials and conditions can be found in other data sections.

Properties of Materials 37

Typical properties and uses of the important engineering materials. Most of the information is given in a standard tabular form, making comparison easy, and test conditions are summarized where known. A list of helpful suppliers' bulletins appears at the beginning of each section, and advertisements appear at the end of each section.

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Data on the common forms (castings, moldings, etc.) of engineering materials. Much of the information is in tabular form. A list of suppliers' bulletins appears at the beginning of the section, and advertisements of suppliers appear at the end.

Joining & Fastening of Materials 431

Data on the joining and fastening methods used for engineering materials. A list of helpful bulletins available from suppliers appears at the beginning of the section, and advertisements of suppliers appear at the end.

Suppliers of Materials 465

An alphabetical index to the important engineering materials and forms of materials, containing under each heading the names of the leading suppliers.

Addresses of Suppliers 524

An alphabetical list of the names and addresses of the suppliers of engineering materials and forms mentioned in the Directory.

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Addresses of Suppliers

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How to Use the Selector

Naturally, you can use this issue in many different ways, depending upon the nature of your own materials problems. However, this issue is called the *Materials Selector* because it is designed to help you systematically narrow your choice of materials, parts and finishes to meet a specific problem. Here is a logical procedure:

1. See Comparisons of Materials.

Look up the critical properties and see which materials warrant further investigation.

2. See Index to Data.

3. See Properties of Materials.*

Look up the pages indicated by the Index. Reduce the number of materials requiring further study by comparing significant properties, available forms and typical uses.

4. See Forms and Shapes of Materials.

Narrow the choice of materials further by comparing the characteristics of competitive forms and shapes.

5. See Joining and Fastening of Materials.

If assembly is required, limit choice of materials still further by comparing characteristics of competitive joining materials and processes.

6. See Suppliers of Materials.

Look up promising materials and forms to obtain the names of suppliers.

7. See Addresses of Suppliers.

8. Obtain detailed information

on properties, availability and cost of materials and fabricated forms by:

a. Writing to suppliers.

b. Consulting the Suppliers' Literature pages in Properties of Materials sections. Note key numbers of promising bulletins and circle them on free post card (pp 427, 463 or 545).

c. Consulting the advertisements. Names of advertisers are bold faced in the Directory, and the pages on which their advertisements appear are indicated.

***WHAT THE DATA MEAN:**

With the exception of the section on Finishes and Coatings, Properties of Materials consists entirely of tabular data on the properties, forms and uses of engineering materials.

Tabular data on properties generally represent average test results obtained from many different sources and suppliers. Although the values may have been obtained from standard specified tests, in no case do the values represent minimum or maximum specified limits. A range of values may indicate either the normal variation encountered in that particular test, or the differences attributable to variations in the composition, temper, heat treatment, form, or other condition of the material. Where a value or range applies only to a particular condition of the material, the condition is stated.

Available forms listed in these sections are the most important forms that are readily available commercially. Uses listed in these sections are only typical and are not intended to be exhaustive.

These data have a limited purpose. Space does not permit a complete description of the materials and test conditions to which the data apply; hence, these data cannot be used directly for final designs. They are intended solely to aid in the important job of materials selection.

Sorry—No Extra Copies

This issue is not sold separately and is available only to Materials in Design Engineering subscribers. No extra copies sold to subscribers.

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MUrray Hill 8-8600

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Specific Gravity

Material ↓	Average	Range, ±
Osmium	22.7	—
Iridium	22.5	—
Platinum	21.5	—
Tungsten & Gold	19.4	—
Uranium	19.1	—
Tantalum	16.6	—
Tungsten Carbide Cermet	14.1	1.1
Hafnium	13	—
Rhodium	12.4	—
Palladium & Ruthenium	12	—
Tungsten-Titanium Carbide Cermet	11.8	1.2
Thorium	11.6	—
Lead & Its Alloys	11.0	0.3
Silver	10.5	—
Molybdenum	10.2	—
Lead-Base Babbitts	9.96	0.66
Tin Bronzes (cast), High Leaded	9.18	0.32
Copper	8.92	0.03
Cobalt	8.92	—
Nickel Brasses & Bronzes (cast), Leaded	8.87	0.05
Phosphor Bronzes	8.85	0.07
Yellow Brasses (cast)	8.83	1.13
Nickel Silvers	8.77	0.10
Red & Semi-Red Brasses & Tin Bronzes (all cast), Leaded	8.73	0.17
Monel	8.66	0.18
Plain Brasses & Nickel	8.62	0.23
Monel (cast)	8.60	0.24
Columbium	8.6	—
Tin & Aluminum Brasses	8.43	0.09
Duranickel & Inconel	8.26	0.18
Beryllium Coppers	8.22	0.03
Low Expansion Nickel Alloys	8.14	0.06
Carbon & Low Alloy Steels	7.84	—
Stainless Steels	7.78	0.25
Ingot Iron	7.76	—
Wrought Iron	7.70	—
Tin-Base Babbitts	7.55	0.21
Aluminum Bronzes (cast)	7.48	0.08
Chromium Carbide Cermet	7.44	0.46
Austenitic Nodular Irons	7.43	—
Tin & Its Alloys	7.29	0.03
Malleable Irons	7.21	0.08
Gray & Nodular Irons	7.19	0.02
Zinc & Its Alloys	7.17	0.01
Zinc Alloys (cast)	6.65	—
Zirconium	6.65	—
Vanadium	6.38	—
Titanium Carbide Cermet	6.37	0.83
Molybdenum Disilicide	6.08	0.12
Alumina Cermets	5.96	0.14
Titanium & Its Alloys	4.60	0.17
Alumina Ceramics	3.67	0.19
Silicon Nitride	3.43	—
Glasses	3.22	1.06
Micas	3.2	0.6
Whitewares	3.08	0.78
Silicon Carbide	2.82	0.24
Aluminum & Its Alloys	2.72	0.14
Glass Fiber	2.54	—
Boron Carbide	2.41	—
Boron Nitride	2.24	—
TFE Fluorocarbons	2.2	0.1
Phenolics	2.15	0.85
Alkyds	2.12	0.12
CFE Fluorocarbons	2.12	0.03
Epoxies	2.10	1.10
Beryllium	1.86	—
Silicone Plastics	1.82	0.18
Magnesium Alloys	1.81	0.04
Melamines	1.74	0.26
Vinylidene Chloride	1.71	0.04
Plastics Laminates, Low Pressure	1.7	0.5
Carbon & Graphite	1.57	0.07
Plastics Laminates	1.52	0.38
Bast Fiber	1.51	0.04
Diallyl Phthalate	1.5	0.2
Ureas	1.49	0.03
Cellophane	1.48	0.07
Hard Rubber	1.46	0.26
Animal Fiber	1.45	0.15
Acetal	1.43	—
Chlorinated Polyether	1.4	—
Allyls (cast)	1.38	0.08
Polyvinyl Chloride	1.35	0.20
Polysulfide Rubber	1.35	—
Polystyrenes & Nylons, Glass Fiber-Filled	1.33	0.02
PVC-Nitrile Rubber Blend Film	1.27	0.08
Polyvinyl Alcohol	1.26	0.05
Polyesters (cast)	1.25	0.20
Neoprene, Silicone & Urethane Rubbers	1.25	—
Polycarbonate	1.20	—
Polysulfide-Epoxy (cast)	1.19	0.04
Acrylics, GP	1.18	0.01
Wood Comp Board, Hard	1.17	0.28
Cellulosics	1.15	0.15
Acrylics, High Impact	1.14	0.02
Rubber Hydrochloride Film	1.14	0.01
Nylons 6 & 66	1.13	0.05
Polystyrenes & Methylstyrenes	1.06	0.06
ABS Resins	1.04	0.03
Nitrile Rubber	1	—
Polyethylenes	0.94	0.03
Styrene-Butadiene Rubber	0.94	—
Natural Rubber	0.93	—
Polypropylene	0.91	—
Butyl Rubber	0.9	—
Wood Comp Board, Particle	0.73	0.32
American Woods	0.53	0.16
Epoxy Foamed-in-Place	0.51	0.11
Sheet Felts	0.473	0.217
Cellular Polyethylene	0.47	—
Wood Comp Board, Soft	0.41	—
Prefoamed Epoxy	0.328	0.280
Neoprene Flexible Foam	0.321	0.160
Filter Felts	0.313	0.169
Flexible Nitrile Foam	0.281	0.120
Prefoamed Silicone Rubber	0.256	—
Roll Felts	0.245	0.092
Silicone Rubber Foamed-in-Place	0.208	0.016
Urethane Rubber Foamed-in-Place	0.204	0.197
Urethane Flexible Foam	0.168	0.152
Prefoamed Modified Polystyrene	0.125	0.015
Latex Flexible Foam	0.104	0.008
Phenolic Foamed-in-Place	0.096	0.064
Polystyrene Foamed-in-Place	0.096	0.064
Cellular Cellulose Acetate	0.096	0.032
Styrene-Butadiene Flexible Foam Rubber	0.072	—
Vinyl Flexible Foam	0.064	—
Prefoamed Polystyrene	0.048	0.019
Prefoamed Urea	0.016	0.003

Thermal Conductivity[a]

Btu/hr/sq ft/°F/ft

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Silver[b]	242	—	Titanium Alloys[b]	5.2	1.5
Copper	211	—	Calcia[c]	4.12	—
Gold[b]	172	—	Carbon[b]	4	1
Beryllium Copper	105	—	Ceramics, Elec & Mech	2.06	1.19
Aluminum & Its Alloys	101.2	33.8	Polycrystalline Glass	1.62	0.48
Tungsten[b]	96.6	—	Magnesia[c]	1.47	—
Plain Brasses	88	21	Wood Comp Board, Hard	1.33	0.52
Beryllium	87	—	Silicon Nitride[c]	0.9	—
Molybdenum[b]	84.5	—	Silica[c]	0.80	—
Graphite[b]	78.8	8.0	Glasses[b]	0.63	0.18
Phosphor Bronzes	74.5	45.5	Wood Comp Board, Particle	0.6	0.2
Aluminum Alloys (cast)	71.8	20.7	Zirconia[c]	0.53	—
Tin Brasses	65.5	1.5	Silicone Plastics	0.529	0.441
Zinc & Its Alloys	61.4	0.8	Wood Comp Board, Soft	0.52	0.28
Aluminum Brass	58	—	Alkyds, GP	0.475	0.125
Magnesium Alloys	54.5	25.5	Polyvinyl Alcohol	0.46	—
Rhodium[b]	50	—	Epoxies	0.45	0.35
Magnesium Alloys (cast)	48.4	24.2	Melamines, Filled	0.33	0.08
Platinum[b]	42	—	Micas	0.32	0.09
Palladium[b]	41	—	Phenolics, Elec	0.29	0.05
Cobalt	39.8	—	Alkyds, High Str	0.25	0.05
Ingot Iron[b]	38	—	Cellular Polyethylene	0.25	0.05
Tungsten Carbide Cermet[b]	37.9	12.2	Phenolics, Shock & Ht Res	0.243	0.147
Grade A Tin	37	—	Plastics Laminates, High Pressure	0.23	0.06
Nickel Steels[b]	36.5	2.3	Ureas	0.207	0.037
Wrought Iron[b]	34.5	—	Polyethylenes	0.19	—
Red Brasses (cast), Leaded	36	—	Silicone Rubber	0.177	0.017
Nickel[b]	35.1	0.9	Roll Felts	0.16	0.14
Iridium[b]	34	—	Nylons, Soluble	0.16	—
Tin Foil	34	—	Cellulose Acetate & Propionate	0.145	0.045
Tantalum[b]	31.5	—	Nitrile Rubber	0.143	—
Nitriding Steels[b]	30	—	TFE Fluorocarbons	0.142	—
Standard Malleable Iron	29.5	—	Phenolics, GP	0.133	0.037
Gray Irons[b]	29	5	Cellulose Nitrate Sheet	0.133	—
Aluminum Bronzes (cast)	27.5	5.5	Acetal	0.13	—
Tin Bronzes (cast), Leaded	27.5	0.5	Ethyl Cellulose	0.129	0.038
Carbon & Low Alloy Steels[b]	27	—	Acrylics	0.125	0.025
Nickel Silvers	21.5	—	Nylons	0.12	0.02
Thorium	21.4	—	Allyls (cast)	0.118	0.003
Soft Leads[b]	19.5	0.2	Neoprene Rubber	0.112	—
Nodular Irons[b]	19	1	Polyesters (cast), Rigid	0.11	0.01
Hard Lead Alloys[b]	17.5	1.5	Polycarbonate	0.11	—
Silicon Carbide[c]	17	8	ABS Resins	0.10	0.02
Boron Carbide[c]	16	—	Polyvinyl Formal	0.089	—
Boron Nitride[c]	15.4	—	Polyvinyl Chloride	0.085	0.015
Stainless Steels[b]	15.3	5.9	Natural Rubber	0.082	—
Nickel Silvers (cast)	15	1	Rubber Phenolics	0.08	0.04
Nickel Brasses & Bronzes (cast), Leaded	15	1	Polypropylene	0.08	—
			Epoxy Foamed-in-Place	0.067	—
Uranium	14.5	—	Polystyrenes	0.064	0.016
Lead-Base Babbitts[b]	14	—	Vinylidene Chloride	0.053	—
Monel[b]	13.1	2.3	Butyl Rubber	0.053	—
Tantalum Carbide	12.8	—	CFE Fluorocarbons	0.035	—
Zirconium Carbide	11.9	—	Prefoamed Epoxy	0.034	0.120
High Alloy Steels (cast)[b]	11.4	3.8	Cellular Cellulose Acetate	0.026	0.002
Stainless Steels (cast)[b]	11.3	3.2	Urethane Rubber Foamed-in-Place	0.025	0.005
Duranickel[b]	11	2	Neoprene Flexible Foam	0.025	0.004
Titanium Carbide	9.9	—	Silicone Rubber Foam	0.025	—
Titanium[b]	9.8	—	Latex & Nitrile Flexible Foams	0.023	0.002
Zirconium[b]	9.6	—	Prefoamed Polystyrene	0.022	0.002
Beryllia[c]	9.52	—	Phenolic Foamed-in-Place	0.021	0.002
Inconel[b]	8.7	—	Polystyrene Foamed-in-Place	0.020	0.002
Alumina Ceramics[b]	8.5	2.3	Styrene-Butadiene Flexible Foam	0.018	—
Columbium Carbide	8.23	—	Prefoamed Urea	0.016	0.002
Low Expansion Nickel Alloys[b]	6.48	0.43	Thoria[c]	0	—

[a] Values at room temperature except where noted.

[b] Value at temperature between 120 and 212 F.

[c] Value at temperature > 1800 F.

Coefficient of Thermal Expansion[a]

10^{-6} in./in./°F

Material	Average	Range, ±	Material	Average	Range, ±
Polyethylene	125	42	Low Alloy Steels (cast)[b]	8.15	0.15
Vinylidene Chloride[d]	87.8	—	High Carbon Steels[b]	8.1	—
Polyvinyl Butyral[d]	85.5	41.5	Gold	7.9	—
Cellulosics[d]	77	33	Magnesia[c]	7.78	—
Polypropylene[d]	62	—	Nickel & Its Alloys	7.7	1.3
Nylons[d]	58.5	12.5	Calcia[c]	7.55	—
TFE Fluorocarbons	55	—	Wrought Iron	7.4	—
Polyvinyl Alcohol[d]	52.6	13.9	Martensitic Stainless Steels[b]	6.9	0.4
ABS Resins[d]	51.5	4.5	Cobalt[d]	6.8	—
Acrylics (cast)[d]	50	—	Ingot Iron	6.8	—
Polyester (cast), Rigid[d]	47.5	8.5	Standard Malleable Irons	6.6	—
Acetal[d]	45	—	Nitriding Steels[b]	6.5	—
Chlorinated Polyether	44	—	Palladium	6.5	—
Phenolics (cast), Decorative[d]	44	11	Titanium Alloys[b]	6.4	0.7
Allyls (cast)[d]	42	14	Beryllium	6.4	—
Hard Rubber[d]	40	—	Thorium[d]	6.2	—
Polystyrenes[d]	39	17	Chromium Carbide Cermet	6.05	0.25
Polycarbonate[d]	39	—	Gray Irons	6	—
CFE Fluorocarbons	38.8	—	Titanium Carbide Cermet[b]	5.9	1.6
Phenolics (cast), Mech & Chem[d]	38.5	5.4	Ferritic Stainless Steels	5.9	0.2
Prefoamed Polystyrene[d]	35	15	Age Hardening Stainless Steels	5.85	0.35
Acrylics[d]	35	5	Titanium[b]	5.8	—
Plastics Laminates, GP[d]	34.5	23.5	Beryllium Carbide[b]	5.8	—
Epoxies (cast)[d]	33.5	16.5	Beryllia & Thoria[c]	5.28	—
Polysulfide-Epoxy (cast)	33	22	Ruthenium[d]	5.1	—
Polyvinyl Chloride, Rigid[d]	30.5	2.5	Molybdenum Disilicide[c]	5.1	—
Silicone Plastics, GP[d]	30.1	2.2	Alumina Cermets[b]	4.95	0.25
Urethane Rubber Foamed-in-Place[d]	29.5	14.5	Soda-Lime Glass	4.95	0.15
Epoxy Foamed-in-Place[d]	25.2	14.8	Lead Silicate Glass	4.9	0.2
Silicone Rubber Foamed-in-Place[d]	22.5	2.5	Platinum	4.9	—
Cellular Cellulose Acetate[d]	22.5	2.5	Vanadium[d]	4.8	—
Melamines, Filled[d]	21.1	10.6	Forsterite	4.72	—
Phenolics, GP	20.8	4.2	Plastics Laminates, Mech & Elec[d]	4.6	1.5
Micas[d]	20.7	6.3	Rhodium[d] & Tantalum Carbide[d]	4.6	—
Alkyds[d]	20	10	Silicone Plastics, High Impact[d]	4.5	—
Prefoamed Epoxy[d]	19	3	Boron Nitride[b]	4.3	—
Zinc and Its Alloys[d]	18.9	0.5	Titanium Carbide[b]	4.1	—
Soft Leads[d]	16.3	—	Alumina Ceramics	3.85	0.15
Phenolics, Shock & Ht Res[d]	15.6	7.4	Columbium[b]	3.82	—
Hard Lead Alloys	15.2	0.8	Iridium[d]	3.8	—
Zinc Alloys (cast)	15.2	—	Zirconium Carbide[b]	3.7	—
Rubber Phenolics[d]	15.1	6.9	Steatite	3.66	0.33
Magnesium Alloys	15	1	Tantalum[d] and Osmium[d]	3.6	—
Epoxies[d]	14	—	Hafnium[d]	3.4	—
Ureas[d]	13.6	1.4	Tungsten Carbide Cermet[b]	3.2	0.7
Aluminum & Its Alloys	13.5	1.0	Zirconium[d]	3.1	—
Grade A Tin	13	—	Zirconia[c]	3.06	—
Lead-Base Babbitts	12.7	1.9	Molybdenum[d]	3	—
Phenolics, Elec[d]	12.5	1.9	Silicon Carbide	2.4	—
Aluminum Alloys (cast)	12.5	1.1	Aluminum Silicate Glass	2.3	—
Uranium	12.1	—	Tungsten[d]	2.2	—
Yellow Brasses (cast)	11.5	0.5	Borosilicate Glass	2.15	0.35
Silver	10.9	—	Cordierite	2.08	—
Copper & Its Alloys	10.4	1.4	Standard Electrical Ceramics	2	—
Austenitic Nodular Irons	10.4	—	Polycrystalline Glass	1.77	1.39
Austenitic Stainless Steels[d]	9.85	0.35	Boron Carbide	1.73	—
Nickel & Its Alloys (cast)[b]	9.03	0.17	Zircon	1.57	0.27
High Alloy Steels (cast)[b]	8.45	2.05	Carbon	1.4	0.1
Stainless Steels (cast)[b]	8.4	2	Silicon Nitride[b]	1.37	—
Free-Cutting Steels[b]	8.4	—	Plastics Laminates, Low Pressure[d]	1.2	0.2
Medium & Low Carbon Steels[b]	8.35	0.05	Graphite	1.15	0.15
Carbon Steels (cast)[b]	8.3	—	Silica Glass	0.37	0.07
Low Alloy Steels[b]	8.2	0.1	Silica, Vitreous	0.28	—

[a] Values for a temperature *range* except where noted. The lower temperature is room temperature. The higher temperature is a value between 212 and 750 F except where noted.

[b] Value for a temperature range between room temperature and 1200–1650 F.

[c] Value for a temperature range between room temperature and 2200–2875 F.

[d] Value at room temperature only.

Melting Points of Metals and Ceramics

Fahrenheit

Material ↓	Average	Range, ±
Tungsten	6152	—
Thoria	6000	—
Tantalum	5425	—
Magnesia	5070	—
Osmium	4890	—
Molybdenum	4760	—
Calcia	4710	—
Zirconia	4710	—
Beryllia	4620	—
Ruthenium	4530	—
Iridium	4450	—
Columbium	4379	—
Molybdenum Disilicide	3685	90
Rhodium	3571	—
Silicon Nitride	3452	—
Hafnium	3400	—
Alumina Cermets	3362	—
Zirconium	3355	—
Platinum	3224	—
Titanium	3135	—
Vanadium	3100	—
Thorium	3074	—
Fused Silica Glass	3050	—
Boron Nitride	3000	—
Palladium	2829	—
Ceramic Fiber	2800	—
96% Silica Glass	2800	—
Ingot Iron	2794	—
Wrought Iron	2750	—
Low & Medium Carbon Steels	2735	35
Low Alloy Steels (43XX, 86XX, 87XX)	2740	—
Cobalt	2723	—
Ferritic Stainless Steels	2695	95
Martensitic Stainless Steels	2650	150
Stainless Steels (cast)	2650	100
Nickel	2620	10
Austenitic Stainless Steels	2600	50
Low Alloy Steels (23XX, 25XX)	2600	20
High Alloy Steels (cast)	2550	200
Nickel (cast)	2520	75
Asbestos Fiber	2470	300
Nickel Alloys	2458	158
Beryllium	2341	—
Nodular Irons	2150	100
Uranium	2071	—
Glass Fiber	2000	500
Copper	1960	20
Gold	1945	—
Copper Alloys	1790	160
Silver	1761	—
Copper Alloys (cast)	1695	145
Aluminum Silicate Glass	1675	—
Other Silicate & Soda-Lime Glasses	1290	210
Aluminum & Its Alloys	1053	163
Magnesium Alloys	1010	190
Zinc & Its Alloys	756	36
Soft Lead	620	3
Tin-Base Babbitts	570	220
Hard Lead Alloys	550	60
Pewter	520	45
Lead-Base Babbitts	500	40
White Metal	475	—
Hard Tin	443	—

Maximum Service Temperatures of Plastics and Rubber

Fahrenheit

Material ↓	Average	Range, ±
TFE Fluorocarbon Film	575	10
Silicone Rubber	550	—
TFE Fluorocarbons	500	—
Polyester Film	490	—
Silicone Plastics	450	—
Fluorinated Acrylic and Viton Rubbers	450	—
Diallyl Phthalate	400	100
CFE Fluorocarbons	380	—
Nylon 6 Film	380	—
Plastics Laminates, Low Pressure	375	125
Phenolics, Shock & Ht Res	350	100
Melamines, Glass Fiber-Filled	350	50
Nylon, Glass Fiber-Filled	350	50
Alkyds, High Str	350	—
CFE Fluorocarbon Film	348	47
Cellophane	338	37
Phenolics, Elec	325	75
Alkyds, GP	320	25
Phenolics, GP	320	25
Prefoamed Epoxy	320	25
Cellulose Acetate Film	300	100
Melamines, Cellulose or Mineral-Filled	300	95
Butyl Rubber	300	50
Allyls (cast)	300	—
Phenolic Foamed-in-Place	300	—
Polypropylene Film	300	—
Nylon 66	290	12
Vinylidene Chloride Film	290	—
Plastics Laminates, Elec	280	120
Cellular Cellulose Acetate	270	75
Polysulfide-Epoxy (cast)	270	25
Polyester (cast), Rigid	270	25
Plastics Laminates, GP	270	25
Urethane Rubber Foamed-in-Place	270	25
Epoxies (cast)	261	139
Rubber Phenolics	260	45
Melamines, Fabric-Filled	250	—
Nitrile Rubber	250	—
Polysulfide Rubber	250	—
Neoprene Rubber	240	—
Urethane Rubber	240	—
Polyethylene Film	225	25
Nylon 6	220	25
Polyester (cast), Nonrigid	220	25
Plastics Laminates, Mech	220	25
Nylon 610	220	—
Hard Rubber, GP	220	—
Polyvinyl Chloride Film, Rigid	210	10
Methylstyrenes	210	—
Melamines, Unfilled	210	—
Nitrile Flexible Foam	210	—
Rubber Hydrochloride Film	205	—
Urethane Flexible Foam	200	—
Prefoamed Urea	200	—
Polyethylene Film	200	—
PVC-Nitrile Rubber Blend Film	200	—
Vinylidene Chloride	191	21
Acetal	185	—
Mod Polystyrenes, Ht & Chem Res	183	7
Polyvinyl Chloride, Nonrigid	180	40
Natural Rubber	180	—
Styrene-Butadiene Rubber	180	—
Neoprene Flexible Foam	180	—
Polystyrene Foamed-in-Place	180	—
Acrylics	170	30
Polystyrene Film	170	10
Ureas	170	—
Polyvinyl Chloride Film, Nonrigid	165	15
Polyvinyl Chloride, Rigid	160	8
Prefoamed Polystyrene	160	5
Latex Flexible Foam	160	—
Styrene-Butadiene Flexible Foam	160	—
Polyvinyl Formal	150	17
Polystyrenes, GP	150	10
Cellulose Nitrate Film	140	—
Nylons, Soluble	140	—
Polyvinyl Butyral	110	—

Electrical Resistivity[a]

Microhm-cm

Material ⬇	Range
TFE Fluorocarbons	10^{25}
Polystyrenes, GP	10^{24}-10^{25}
CFE Fluorocarbons	10^{24}
Polypropylene	$>10^{22}$
Polycarbonate	2.1 x 10^{22}
Acrylics, High Impact	2 x 10^{22}
96% Silica Glass[b]	$>10^{21}$
Nylons, Glass Fiber-Filled	4.9-5.7 x 10^{21}
Acrylics (cast)	10^{21}
Polyethylene	10^{21}
Aluminum Silicate Glass[b]	10^{21}
Fused Silica Glass[b]	10^{21}
Urethane Rubber Flexible Foam	6.8-8.3 x 10^{20}
Polymethylstyrene	2.6-5000 x 10^{20}
Polystyrenes, Glass Fiber-Filled	1-67 x 10^{20}
Vinylidene Chloride	10^{20}-10^{22}
Mod Polystyrenes, Med & High Impact	10^{20}-10^{22}
Alumina Whitewares	10^{20}-10^{21}
Acrylics, GP & Alkyds	10^{20}
Cordierite, Forsterite & Steatite	10^{20}
Lead Silicate Glass[b]	10^{20}
Polyvinyl Butyral	10^{20}
Polyvinyl Chloride, Rigid	10^{20}
Zircon Whitewares	10^{20}
Allyls (cast)	$>10^{19}$
Acetal	>4 x 10^{19}
Silicone Plastics	>3.4 x 10^{19}
Nylon 66	4.5 x 10^{19}
Nylon 11	2 x 10^{19}
Boron Nitride	1.7 x 10^{19}
Mod Polystyrenes, Ht & Chem Res	10^{19}-10^{23}
Micas	10^{19}-10^{23}
Nylon 6	10^{19}-10^{21}
Standard Electrical Whitewares	10^{19}-10^{21}
Epoxy Foamed-in-Place	10^{19}
Polyesters (cast), Rigid	10^{19}
Phenolics, Elec	6-10 x 10^{18}
ABS Resins	5-82 x 10^{18}
Phenolics (cast), Mech & Chem	1-7 x 10^{18}
Phenolics (cast), Decorative	1-3 x 10^{18}
Mod Polystyrenes, Extra High Impact	10^{18}-10^{23}
Cellulose Propionate	10^{18}-10^{21}
Ethyl Cellulose	10^{18}-10^{20}
Borosilicate Glass[b]	10^{18}
Polyesters (cast), Nonrigid	10^{18}
Polyvinyl Chloride, Nonrigid	4-7000 x 10^{17}
Phenolics (cast), Transparent	3 x 10^{17}
Methylstyrene-Acrylonitrile	2.6 x 10^{17}
Glass Fiber	2 x 10^{17}-10^{21}
Plastics Laminates, Low Pressure	1-14,000 x 10^{17}
Melamines, Glass Fiber-Filled	1-7 x 10^{17}
Cellulose Nitrate Sheet	1.0-1.5 x 10^{17}
Epoxies (cast)	10^{17}-10^{20}
Melamines, Cellulose and/or Mineral-Filled	10^{17}-10^{20}
Ureas	5-50 x 10^{16}
Cellulose Acetate	10^{16}-10^{19}
Phenolics, Shock & Ht Res	10^{16}-10^{19}
Cellulose Acetate Butyrate	10^{16}-10^{18}
Chlorinated Polyether	5 x 10^{15}
Soda-Lime Glass[b]	4 x 10^{15}
Phenolics, GP	10^{15}-10^{19}
Melamines, Fabric-Filled	10^{15}-10^{18}
Diallyl Phthalate	1-250 x 10^{14}
Rubber Phenolics	10^{12}-10^{17}
Polycrystalline Glass	1.26-100 x 10^{8}
Beryllium Carbide	1.1 x 10^{6}
Carbon	3500-4600
Graphite	800-1300
Titanium Carbide	105
Austenitic Nodular Irons	102
Inconel	98.1
Titanium Alloys	91-175
Columbium Carbide	74
Age Hardening Stainless Steels	71-100
Stainless Steels (cast)	71-90
High Alloy Steels (cast)	70-112
Austenitic Stainless Steels	69-72
Nodular Irons	66-68
Zirconium Carbide	63.4
Ferritic Stainless Steels	60-67
Titanium	55
Monel (cast)[c]	53.2-63.1
Gray Irons	50-200
Monel	48.2-58.3
Low Expansion Nickel Alloys	48-81
Duranickel[c]	46.5
Martensitic Stainless Steels	40-72
Zirconium	40
Pearlitic Malleable Irons	38.2-41.2
Standard Malleable Irons	32
Low Alloy Steels (43XX, 86XX, 87XX)[b]	30
Hafnium[c]	30
Nitriding Steels	27-29
Low Alloy Steels (23XX, 25XX)[b]	27-29
Lead-Base Babbitts	25.6-28.7
Uranium	25-50
Vanadium	25
Hard Lead Alloys	22.0-27.1
Low Alloy Steels (61XX)	21.0
Nickel (cast)[c]	20.8
Soft Leads	20.6
Tantalum Carbide	20
Low Alloy Steels (92XX, 94XX)	19-20
Low Alloy Steel (40XX)	19
Medium Carbon Steels	19
Thorium	18
High Carbon Steels	18
Manganese Steels	17
Low Alloy Steels	15-20
White Metal	15
Platinum[c]	14.9
Free-Cutting Steels	14.3
Low Carbon Steels	14.3
Columbium	14.2
Magnesium Alloys (cast), Sol'n Tr	14.0-17.5
Carbon Steels (cast)	13-16
Tantalum	12.4
Tin Foil	12
Inconel (cast)[c]	11.6-12.6
Grade A Tin	11.5
Palladium	10.8
Ingot Iron	9.7
Nickel[c]	9.5
Osmium	9.5
Admiralty Metal, Ann.	8.9
Ruthenium[c]	7.6
Aluminum Bronzes (cast)	7.5-13.5
Aluminum Brass, Ann.	7.5
Manganese Bronze, Ann.	7.2
Zinc Alloys (cast)	6.37-6.54
Zinc Alloys (HR)	6.22-6.31
Zinc (CR)	6.10
Magnesium Alloys (cast)	6.6-17
Naval Brass, Ann.	6.6
Yellow Brass, Ann.	6.4
Muntz Metal, Ann.	6.2
Cartridge Brass, 70%, Ann.	6.2
Zinc (HR)	6.06
Tungsten[c]	5.5
Low Brass, 80%, Ann.	5.4
Iridium	5.3
Molybdenum[c]	5.2
Magnesium Alloys	5-14.5
Beryllium Coppers, Ann.	4.82-5.82
Rhodium	4.51
Red Brass, 85%, Ann.	4.7
Commercial Bronze, 90%, Ann	3.9
Phosphor Bronzes, Ann.	3.6-16
Gilding, 95%, Ann.	3.1
Aluminum & Its Alloys, Hard	3.0-6.4
Aluminum & Its Alloys, Ann.	2.93-5.94
Gold[c]	2.35
Copper, Ann.	1.71-2.03
Silver	1.59

[a] Values or ranges at room temperature except where noted.
[b] Value or range at a temperature between 120 and 212 F.
[c] Value or range at 32 F.

Dielectric Strength of Nonmetallics

v/mil[a]

Material	Average	Range, ±
Mica	1500	500
Polymethylstyrene	1420	530
Polyvinyl Chloride, Rigid	1063	337
Polypropylene	795	25
Methylstyrene-Acrylonitrile	610	—
CFE Fluorocarbons	565	35
Nylon, Glass Fiber-Filled	504	16
Modified Polystyrenes	480	170
Acetal	500	—
Polyethylenes	480	—
Acrylics (cast)	475	25
Hard Rubber	472	128
Polystyrene	470	30
Polyester, Rigid	455	115
Plastics Laminates, Low Pressure	450	350
Cellulose Nitrate	450	150
Polyvinyl Formal	450	150
Epoxies	450	100
TFE Fluorocarbons	450	50
Epoxy (cast) & Acrylics	450	50
Nylons	443	57
Mica, Glass-Bonded	435	165
Ethyl Cellulose	425	75
Allyl (cast)	415	85
Polyvinyl Butyral, Polycarbonate & Chlorinated Polyether	400	—
Melamines, Electrical	390	40
Diallyl Phthalate, Glass Fiber-Filled	388	42
ABS Resins, Med-High Impact	378	38
Phenolics (cast)	375	75
Cellulose Propionate	375	75
Diallyl Phthalate, Asbestos-Filled	354	24
Ureas	350	50
Phenolics, High Freq	338	38
Plastics Laminates, High Pressure	335	265
Silicones & Cellulose Acetate Butyrate	325	75
Alkyds	325	25
Melamines, GP	320	10
Phenolics, GP & Shock Res	313	113
ABS Resins, Extra-High Impact	312	—
Polyester, Nonrigid	310	90
Cellulose Acetate	308	58
Melamines, Glass Fiber-Filled	275	25
Phenolics, Rubber	263	13
Polyvinyl Chloride, Nonrigid	262	238
Melamines, Shock Res	250	120
Alumina Ceramics	250	50
Phenolics, Chem Res	250	25
Forsterite	250	—
Phenolics, Heat Res	225	125
Steatite	213	67
Cordierite	185	45
Standard Electrical Ceramics	178	122
Zircon	175	115
Phenolics (cast), Transp.	163	87

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[a] Short-time.

Dielectric Constant of Nonmetallics[a]

Material	Average	Range, ±
Alumina Ceramics	8.9	0.7
Mica, Glass-Bonded	8.25	1.25
Lead Silicate Glass	8.1	1.5
Phenolics (cast), GP	8	3
Soda-Lime Glass	7.3	0.1
Zircon	7.25	1.95
Mica, Muscovite	7.05	1.65
Melamines, Glass Fiber-Filled	7.05	0.15
Polyvinyl Chloride, Nonrigid	7	1
Ureas	6.65	0.25
Melamines, Shock Res	6.5	0.4
Mica, Fluor-Phlogopite	6.5	—
Phenolics, Heat Res	6.4	1.6
Cellulose Nitrate	6.4	—
Forsterite	6.35	0.15
Aluminum Silicate Glass	6.3	—
Phenolics, Chem Res	6.25	0.75
Standard Electrical Ceramics	6.2	0.8
Polycrystalline Glass	6.18	0.60
Steatite	6.0	0.5
Melamines, GP	5.7	0.1
Phenolics, GP & Shock Res	5.5	1.5
Cordierite	5.16	1.08
Cellulose Acetate	5.1	1.9
Plastics Laminates, High Pressure	5.1	1.7
Phenolics, Rubber	5	—
Polyester, Nonrigid	4.9	1.2
Phenolics (cast), Mech, Chem & High Freq	4.75	0.75
Cellulose Acetate Butyrate	4.7	1.5
Borosilicate Glass	4.6	0.6
Polysulfide-Epoxy (cast)	4.5	1.5
Plastics Laminates, Low Pressure	4.5	1.1
Alkyds	4.5	0.5
Silicones	4.35	0.75
Boron Nitride	4.15	—
Allyl (cast)	4.05	0.75
Epoxy, Foamed-in-Place	4	2
Vinylidene Chloride	4	1
Diallyl Phthalate	4.0	0.7
Nylons	3.95	0.55
Hard Rubber	3.85	0.95
Silica Glass	3.8	—
ABS Resins, Extra High Impact	3.78	—
Epoxy (cast) & Acetal	3.6	0.1
Cellulose Propionate	3.5	0.1
ABS Resins, Med-High Impact	3.45	0.65
Nylon, Glass Fiber-Filled	3.41	0.04
Polyester, Rigid	3.4	0.6
Polyvinyl Butyral	3.33	—
Ethyl Cellulose	3.2	0.4
Polyvinyl Formal	3	—
Polycarbonate	2.96	—
Acrylics (cast)	2.95	0.25
Methylstyrene-Acrylonitrile & Chlorinated Polyether	2.81	—
Modified Polystyrenes, Med-High Impact	2.8	0.3
Modified Polystyrenes, Extra High Impact	2.6	0.7
Urethane Flexible Foam	2.55	0.35
Acrylics	2.5	0.5
Polyvinyl Chloride, Rigid	2.5	0.2
Polymethylstyrene	2.48	—
Polystyrene	2.46	0.26
CFE Fluorocarbons	2.34	0.04
Polyethylenes	2.3	—
Polypropylene	2.05	0.05
TFE Fluorocarbons	2.0	—
Polyethylene Flexible Foam	1.49	—
Prefoamed Epoxy	1.47	0.43
Prefoamed Silicone	1.26	—
Urethane Rubber & Silicone Foamed-in-Place	1.23	0.17
Prefoamed Cellulose Acetate	1.11	0.01
Prefoamed & Foamed-in-Place Polystyrene	1.06	0.01

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[a] At 10^6 cycles.

Specific Heat

Btu/lb/°F

Material	Average	Range, ±
Polyethylene	0.54	0.01
Polypropylene	0.46	—
Nylons	0.44	0.14
Polyester, Rigid	0.43	0.13
Allyl (cast)	0.41	0.15
Phenolics, GP	0.38	0.02
ABS Resins	0.37	0.01
Cellulose Acetate	0.36	0.06
Cellulose Propionate & Cellulose Acetate Butyrate	0.35	0.05
Acetal	0.35	—
Hafnium	0.35	—
Acrylics	0.34	0.1
Polystyrene, GP	0.34	0.01
Med Polystyrenes	0.33	0.02
Phenolics, High Shock	0.33	0.02
Phenolics, Rubber	0.33	—
Vinylidene Chloride	0.32	—
Silicon Carbide	0.31	0.02
Phenolics, Very High Shock	0.30	0.02
Prefoamed Polystyrene	0.27	—
Mica, Fluor-Phlogopite	0.25	—
TFE Fluorocarbons	0.25	—
Magnesium Alloys	0.25	—
Aluminum-Magnesium-Silicon & Aluminum-Zinc Alloys	0.23	—
CFE Fluorocarbons	0.22	—
Aluminum & Its Alloys	0.22	—
Soda-Lime Glass	0.2	—
Mica, Muscovite	0.2	—
Mica, Glass-Bonded	0.19	0.06
Borosilicate Glass	0.19	—
Silica Glass	0.18	—
Carbon & Graphite	0.18	—
Lead Silicate Glass	0.17	0.01
Chromium-Alumina Cermet	0.16	—
Palladium	0.158	—
Molybdenum-Chromium-Alumina Cermet	0.14	—
Malleable Irons	0.133	—

Material	Average	Range, ±
Low Carbon & A Nickels	0.130	—
Monel	0.127	—
Titanium & Its Alloys	0.126	0.007
Heat Resistant Alloys (cast)	0.125	0.015
Stainless Steels (cast)	0.125	0.015
Low-Expansion Nickel Alloys	0.122	0.002
Nickel Alloys (cast)	0.12	0.01
Vanadium	0.12	—
Austenitic Stainless Steels	0.12	—
Nitriding Steels	0.115	0.005
Low Alloy Steels (23XX, 25XX)	0.115	0.005
Ferritic & Martensitic Stainless Steels	0.11	—
Ingot & Wrought Irons	0.11	—
Inconel	0.109	—
All Other Steels	0.105	0.005
Duranickel	0.104	—
Glass Fibers	0.1	—
Zinc Alloys (cast)	0.1	—
Inconel X	0.1	—
Beryllium Copper	0.1	—
Zinc Alloys	0.095	0.001
Copper	0.092	—
Copper Alloys	0.09	—
Zirconium	0.069	—
Lead-Tin-Antimony Alloys	0.065	—
Molybdenum & Columbium	0.065	—
Rhodium	0.059	—
Ruthenium	0.057	—
Silver	0.056	—
Tin & Its Alloys	0.054	—
Polyvinyl Butyral	0.04	—
Tantalum	0.036	—
Tungsten	0.034	—
Hard Lead & Its Alloys	0.032	—
Iridium & Osmium	0.031	—
Platinum & Gold	0.031	—
Soft Lead & Its Alloys	0.031	—
Polyvinyl Alcohol	0.03	—
Uranium & Thorium	0.03	—

Modulus of Elasticity in Tension[a]

100,000 psi

Material ↓	Average	Range, ±
Osmium	800	—
Tungsten Carbide	780	164
Iridium	740	—
Tungsten-Titanium Carbide Cermet	731	76
Silicon Carbon, Densified	680	—
Ruthenium	600	—
Tungsten	500	—
Titanium Carbide Cermet	495	75
Beryllium	440	—
Boron Carbide	420	—
Molybdenum	420	—
Rhodium	420	—
Alumina Ceramics	410	90
Alumina Cermets	390	20
Inconel	310	—
Cobalt	300	—
Nickel	300	—
Duranickel	300	—
Uranium	300	—
Carbon Steels (cast)	299	2
Ingot Iron	298	—
Carbon & Low Alloy Steels	295	5
Wrought Iron	295	—
Martensitic Stainless Steels	290	—
Ferritic Stainless Steels	290	—
Age Hardening Stainless Steels	288	7
Austenitic Stainless Steels	283	3
Pearlitic Malleable Irons	280	—
High Alloy Steels (cast)	270	20
Tantalum	270	—
Stainless Steels (cast)	265	25
Monel	260	—
Micas	250	50
Standard Malleable Irons	250	—
Inconel (cast)	240	10
Monel (cast)	236	6
Nodular Irons	235	15
Low Expansion Nickel Alloys	225	15
Nickel (cast)	215	—
Platinum	210	—
Hafnium & Vanadium	200	—
Beryllium Coppers	190	—
Nickel Brasses & Bronzes (cast), Leaded	185	35
Austenitic Nodular Irons	185	—
Nickel Silvers	180	20
Copper	170	—
Palladium	170	—
Aluminum & Phosphor Bronzes	165	15
Plain Brasses	160	10
Tin & Aluminum Brasses	155	5
Titanium & Its Alloys	155	12
Silicon Carbide, Bonded	150	20
Polycrystalline Glass	149	24
Gray Irons	145	55
Steatite	145	15
Yellow Brasses (cast)	140	20
Zirconium	140	—
Tin Bronzes (cast), High Leaded	133	27
Boron Nitride	124	—
Red Brasses (cast), Leaded	120	29
Gold	120	—
Semi-Red Brasses (cast), Leaded	110	33
Silver	110	—
Tin Bronzes (cast), Leaded	106	21
Aluminum & Its Alloys	103	3
Thorium	100	—
Standard Electrical Ceramics	100	—
Fused Silica Glass	100	—
96% Silica Glass	97	—
Mica, Glass-Bonded	95	25
Soda-Lime Glass	95	5
Borosilicate Glass	83	15
Lead Silicate Glass	83	7
Pewter	77	—
Tin-Base Babbitts	74.5	1.5
Cordierite	70	—
Magnesium Alloys	65	—
Grade A Tin	62.5	2.5
Epoxy Foamed-in-Place	60	—
Lead-Base Babbitts	42	—
Phenolics, Elec.	40	10
Phenolics, Shock & Ht Res	20.5	12.5
Lead & Its Alloys	20	—
Carbon	19.5	3.5
Haynes Stellite 21	16.8	—
Melamines, Filled	14.7	4.8
Ureas	14.5	1.5
Polystyrenes, Glass Fiber-Filled	12	—
Diallyl Phthalate	11.5	5.5
Graphite	11	3
Phenolics, GP	10.5	2.5
Rubber Phenolics	6.5	2.5
Polyvinyl Formal	6	1
Phenolics (cast), Mech & Chem	4.5	0.5
Polystyrenes, GP	4.5	0.5
Mod Polystyrenes	4.25	1.75
Acrylics, GP	4.25	0.75
Nylon 66	4.05	0.05
Polyesters (cast), Rigid	4.0	2.5
Phenolics (cast), Decorative	3.75	0.75
Polyvinyl Butyral	3.75	0.25
Acrylics, High Impact	2.65	0.35
Nylons 6, 11 & 610	2.55	1.05
Allyls (cast)	2.5	0.5
CFE Fluorocarbons	2.45	0.55
Cellulose Nitrate Sheet	2.05	0.15
Ethyl Cellulose	2.0	1.5
Phenolics (cast), Transparent	2	1
ABS Resins	1.95	0.95
Polypropylene	1.55	—
Vinylidene Chloride	1.35	0.60
Cellulose Propionate	1.1	0.6
TFE Fluorocarbons	0.515	0.135
Nylons, Soluble	0.38	—
Polycarbonate	0.33	—
Polyethylene, Low Density	0.235	0.035
Polyvinyl Chloride, Nonrigid	0.017	0.013

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[a] At room temperature.

Tensile Strength[a]

1000 psi

Material	Average	Range, ±
Rhodium, CW	300	—
Low Alloy Steels (92XX, 94XX), H & T (800 F)	225	33
Low Alloy Steels (41XX), H & T (800 F)	215	15
Low Alloy Steels (43XX, 86XX, 87XX), H & T (800 F)	215	5
Stainless Steels (cast), H & T	210	10
Glass Fiber	208	4
Titanium Alloys, Ht Tr	205	35
Beryllium Coppers, CW & Ht Tr	195	15
Low Alloy Steels (46XX, 48XX), H & T (800 F)	192	8
Nitrided Steels, H & T	190	—
Low Alloy Steels (40XX), H & T	188	80
Martensitic Stainless Steels, H & T	187	98
Tungsten, CW	185	120
Monel, Age H	185	15
Beryllium Coppers, Ann. & Ht Tr	175	10
Age Hardening Stainless Steels, Sol'n Tr & Aged	173	42
High Carbon Steels, H & T (700 F)	169	20
Inconel, Age H	167	13
Asbestos Fiber	158	142
Low Alloy Steels (cast), H & T	155	45
Austenitic Stainless Steels, CW	147	38
Molybdenum, CW	147	28
Low Alloy Steels (61XX), H & T	146	41
Tantalum, CW	145	35
Titanium Alloys, Ann	140	30
Tungsten-Titanium Carbide Cermet	132	13
Monel (cast), Ann. & Aged	132	13
Tungsten Carbide Cermet	130	—
High Carbon Steels (HR)	127	—
Aluminum Silicate Glass	125	17
Low Alloy Steels (23XX, 25XX), H & T (1000 F)	122	18
Sheet Felts	122	10
Inconel, Ann.	120	10
Low Alloy Steels (13XX), H & T (1000 F)	118	18
Phosphor Bronzes, Hard	117	11
Low Expansion Nickel Alloys, CW	115	25
Low Alloy Steels (40XX), CD	113	24
Vanadium, CW	113	—
Roll Felts	112	13
Phosphor Bronzes, Hard	111	36
Low Alloy Steels (13XX), CD	110	9
Medium Carbon Steels, H & T (1000 F)	109	11
High Carbon Steels, Ann.	108	11
Molybdenum, Ann.	107	23
Low Alloy Steels (43XX), Ann.	107	12
High Alloy Steels (cast), Norm. & T	107	—
Nodular Irons	105	45
Duranickel, Ann.	105	15
Austenitic Chromium-Manganese Stainless Steels, Ann.	105	10
Aluminum Bronzes (sand cast), H & T (1000–1150 F)	102	13
Low Alloy Steels (23XX, 25XX), CD	102	8
Low Alloy Steels (48XX), Norm.	101	9
Columbium, CW	100	—
Nickel Silvers, Extra Hard	100	8
Carbon Steels (cast), H & T	100	—
Cobalt, CW	100	—
Low Alloy Steels (40XX), CD & Ann.	98	11
Austenitic Chromium-Nickel Stainless Steels, Ann.	97	13
Low Alloy Steels (13XX), Ann.	97	13
Stainless Steels (cast), Ann.	96	1
Martensitic Stainless Steels, Ann.	95	30
High Alloy Steels (cast), Ann.	95	—
Medium Carbon Steels, CW	94	9
Titanium, Ann.	94	6
Inconel (cast)	92	28
Low Alloy Steels (48XX), Ann.	92	7
Low Alloy Steels (86XX, 87XX), Ann.	91	14
Yellow Brass (cast), High Strength	90	30
Free-Cutting Steel, CD	90	20
Low Alloy Steels (23XX, 25XX), Ann.	90	14
Uranium	90	—
Monel, Ann.	87	18
Zirconium, CW	86	4
Manganese Bronze, Half Hard	84	—
Ferritic Stainless Steels, CW	82	8
Titanium Carbide Cermet	80	54
Cartridge Brass, 70%, Hard	76	—
Low Expansion Nickel Alloys, Ann.	76	6
Tantalum, Ann.	75	25
Pearlitic Malleable Irons	75	15
Beryllium, Ann	75	15
Ferritic Stainless Steels, Ann.	75	10
Naval Brass, Half Hard	75	—
Low Brass, 80%, Hard	74	—
Yellow Brass, Hard	74	—
Ingot Iron, CD	73	—
Rhodium, Ann.	73	—
Beryllium Coppers, CW	72	—
Vanadium, Ann.	72	—
Beryllium Coppers, Ann.	70	10
Red Brass, 85%, Hard	70	—
Muntz Metal, Half Hard	70	—
Low Carbon Steels, CW	69	13
Manganese Bronze, Ann.	65	—
Austenitic Nodular Irons	63	5
Nickel, Ann.	62	13
Aluminum Brass, Ann.	60	—
Aluminum & Its Alloys, T6	59	24
Cobalt, Ann.	56	19
Gilding, 95%, Hard	56	—
Nickel (cast)	57	8
Naval Brass, Ann.	57	—
Nickel Silvers, Ann.	55	6
Standard Malleable Irons	55	5
Commercial Bronze, 90%, Hard	54	—
Muntz Metal, Ann.	54	—
Silver, CW	54	—
Phosphor Bronzes, Ann.	53	13
Admiralty Metal, Ann.	53	—
Columbium, Ann.	50	—
Copper, Hard	50	—
Wrought Iron	48	—
Plastics Laminates, Low Pressure	47	38
Nickel Silvers (sand cast)	47	18
Cobalt (cast)	47	14
Palladium, CW	47	—
Yellow Brass, Ann.	46	—
Gray Irons (cast)	45	30
Nickel Brasses & Bronzes (cast), Leaded	45	20
Micas	45	5
Zinc Alloys (die cast)	44	3
Zirconium, Ann.	44	15

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[a] At room temperature.

continued on next page

Tensile Strength[a]

1000 psi

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Cartridge Brass, 70%, Ann.	44	—	White Metal, Ann.	6.7	—
Ingot Iron, Ann.	42	—	Polystyrenes, GP	6.5	1.5
Low Brass, 80%, Ann.	42	—	Polysulfide Epoxy (cast)	6.5	3.5
Magnesium Alloys (forged)	41	8	Acrylics, High Impact	6.4	0.9
Tin Bronzes (cast), High Leaded	40	8	CFE Fluorocarbon Film	6.4	0.2
Platinum, CW	39	6	Rubber Phenolics	6.2	2.8
Red Brass, 85%, Ann.	39	—	Polyvinyl Butyral	6.2	2.3
Red Brass (cast), Leaded	38	8	Vinylidene Chloride	6	2
Yellow Brass (cast), Leaded	38	7	Mica, Glass-Bonded	6	1
Thorium	37	—	Chlorinated Polyether	6	—
Chromium Carbide	36	1	Urethane Rubber (gum)	>5	—
Semi-Red Brass (cast), Leaded	34	6	Diallyl Phthalate	5.8	1.2
Copper, Ann.	32	—	ABS Resins	5.75	2.75
Gold, CW	32	—	Allyls (cast)	5.7	1.3
Magnesium Alloys (cast)	31	9	Nylons, Soluble	5.6	1.8
Tin Bronzes (cast), Leaded	31	7	Rubber Hydrochloride Film	5.5	0.5
Nickel Silvers (sand cast)	30	2	Hard Lead Alloys (chill cast)	5.4	2
Palladium, Ann.	30	—	Hard Rubber	5.1	3.2
Alumina Ceramics	29	10	CFE Fluorocarbons	5.1	0.6
Aluminum & Its Alloys, Ann.	28.5	16.5	Cellulosics	5.0	3.5
Vinylidene Chloride, Oriented	27	13	Polypropylene	5	—
Zinc (CR)	26	5	Standard Electrical Ceramics	4.7	2.3
Aluminum Alloys (cast)	23	5	Silicone Plastics, High Impact	4.7	0.3
Boron Carbide	22.5	—	Wood Comp Board	4.4	4.3
Polyester Film	22	6	Silicone Plastics, GP	4.1	0.2
Plastics Laminates, High Pressure	22	15	Natural Rubber	4.0	0.5
Silver, Ann.	22	—	Hard Tin (CR)	4.0	—
Platinum, Ann.	21	5	Nitrile Rubber (black)	3.7	0.8
Alumina Cermets	21	—	Polyethylene, High Density	3.7	0.7
Gold, Ann.	19	—	Phenolics (cast), Transparent	3.5	1.0
Gold (cast)	18	—	Alkyds, GP	3.5	0.5
Nylons, Glass Fiber-Filled	16	4	Polyvinyl Alcohol	3	2
Nylon 6 Film	15.4	1.6	Polyvinyl Chloride Film, Nonrigid	3	2
Silver (cast)	15	—	Styrene-Butadiene Rubber (black)	3.0	0.5
Silicon Carbide	14	11	Natural Rubber (gum)	3.0	0.5
Cellophane	13	6	Cordierite	3	—
Polystyrenes, Glass Fiber-Filled	12	2	Grade A Tin (CR)	2.8	—
Nylons 6 & 66	11	1	PVC-Nitrile Rubber Blend Film	2.7	1.3
Vinylidene Chloride Film	11	4	Butyl Rubber	2.7	0.3
Tin-Base Babbitts (chill cast)	10	2	TFE Fluorocarbon Film	2.5	0.5
Forsterite	10	—	Polyethylene Film	2.3	0.7
Cellulosic Films	10	4	Polyvinyl Chloride, Nonrigid	2.2	1.3
Polyvinyl Formal	10	1	TFE Fluorocarbons	2.2	0.8
Acetal	10	—	Polyethylene, Medium Density	2.2	0.2
Steatite	9.9	5.1	Grade A Tin, Ann.	2.2	—
Polycarbonate	9.7	0.8	Soft Leads (chill cast or extr)	2.1	0.1
Polystyrene Film	9.5	2.5	Viton Rubber (gum)	>2	—
Acrylics, GP	9.2	1.3	Polyethylene, Low Density	1.9	0.6
Tin Foil (CR)	8.7	—	Soft Leads (sand cast)	1.8	—
Lead-Base Babbitts (chill cast)	8.6	1.9	Polyesters (cast), Nonrigid	1.4	0.5
Pewter, Ann.	8.6	—	Graphite	1.2	0.8
Nylons 11 & 610	8.5	—	Fluorinated Acrylic Rubber (gum)	1.2	—
Zircon	8.2	3.8	Polysulfide Rubber (gum)	>1	—
Epoxies	8	6	Carbon	1.0	0.1
Acrylics (cast)	8	2	Epoxy Foamed-in-Place	0.9	—
Alkyds, High Str	8	2	Silicone Rubber (gum)	0.8	0.2
Polyvinyl Alcohol Film	8	2	Nitrile Rubber (gum)	0.7	0.2
Methylstyrenes	7.9	1.4	Cellular Polyethylene	0.67	—
Polypropylene Film	7.5	2.5	Prefoamed Modified Polystyrene	0.58	0.52
Melamines, Filled	7.5	2.5	Urethane Rubber Foamed-in-Place	0.50	0.49
Ureas	7.5	2.5	Styrene-Butadiene Rubber (gum)	0.25	0.05
Polyvinyl Chloride Film, Rigid	7.5	1	Cellular Cellulose Acetate	0.15	0.03
White Metal (CR)	7.4	—	Prefoamed Polystyrene	0.11	0.08
Polyvinyl Chloride, Rigid	7.2	1.8	Vinyl Flexible Foam	0.10	0.09
White Metal (cast)	7.2	—	Polystyrene Foamed-in-Place	0.08	0.05
Mod Polystyrenes	7	4	Neoprene Flexible Foam	0.06	0.04
Phenolics	7	3	Phenolic Foamed-in-Place	0.039	0.035
Polyesters (cast), Rigid	7	3	Latex Flexible Foam	0.015	0.005

Elongation[a]

Percent

Material ↓	Average	Range, ±
Butyl Rubber (gum)	850	100
Neoprene Rubber (gum)	850	50
Natural Rubber (gum)	800	50
Butyl Rubber (black)	750	100
Urethane Rubber (gum)	640	110
Polypropylene	600	100
Natural Rubber (black)	600	50
Nitrile Rubber	575	125
Polysulfide Rubber (gum)	550	100
Neoprene Rubber (black)	550	50
Polyethylene Film	500	300
Polyvinyl Alcohol Film	500	100
Styrene-Butadiene Rubber	500	100
Nylons, Soluble	450	150
Polyvinyl Alcohol	450	150
Polyethylene Film	425	375
Rubber Hydrochloride Film	425	75
Polyethylene, Low Density	403	322
Latex Flexible Foam	380	—
PVC-Nitrile Rubber Blend Film	375	125
Viton Rubber (gum)	350	—
Polyvinyl Chloride, Nonrigid	320	130
Cellular Polyethylene	310	—
Nylon 6	300	—
Fluorinated Acrylic Rubber (gum)	300	—
Polyvinyl Chloride Film, Nonrigid	275	225
Silicone Rubber (gum)	230	170
TFE Fluorocarbons	230	120
TFE Fluorocarbon Film	225	25
Polyethylene, High Density	206	194
Polypropylene Film	>200	—
Nylon 11	110	10
Vinyl Flexible Foam	190	110
Polyesters (cast), Nonrigid	170	140
CFE Fluorocarbon Film	145	55
Chlorinated Polyether	110	50
ABS Resins	102	98
Polyester Film	100	30
Duranickel, Ann.	90	40
Polycarbonate	80	20
Epoxies (cast)	76	74
Nylons 66 & 610	73	10
White Metal, Ann.	70	—
Cartridge Brass, 70%, Ann.	66	—
Yellow Brass, Ann.	65	—
Admiralty Metal, Ann.	65	—
Silver (cast)	60	—
Phosphor Bronzes, Ann.	59	11
CFE Fluorocarbons	57	30
Cellulose Acetate Butyrate	56	18
Austenitic Stainless Steels, Ann.	55	5
Cellulose Propionate	55	5
Aluminum Brass, Ann.	55	—
Grade A Tin (cast)	55	—
Low Brass, 80%, Ann.	52	—
Polysulfide-Epoxy (cast)	50	50
Nickel, Ann.	50	10
Soft Leads (rolled)	50	7
Pewter (CR)	50	—
Ingot Iron, Ann.	48	—
Red Brass, 85%, Ann.	48	—
Silver, Ann.	48	—
Zinc (HR)	47	18
Inconel, Ann.	47	8
Ingot Iron (HR)	47	—
Naval Brass, Ann.	47	—
Nickel Silvers, Ann.	45	13
Commercial Bronze, 90%, Ann.	45	—
Copper, Ann.	45	—
Gilding, 95%, Ann.	45	—
Gold, Ann.	45	—
Muntz Metal, Ann.	45	—
Grade A Tin, Ann.	45	—
Cellulose Acetate Film	43	27
Soft Leads (chill cast)	43	4
Beryllium Coppers, Ann.	42	8
Cellulose Acetate, Soft	41	9
Zinc (CR)	40	10
Leaded Naval Brass, Ann.	40	—
Tin Foil (CR)	40	—
Pewter, Ann.	40	—
Thorium	40	—
Hard Lead Alloys (rolled)	38	22
Low Expansion Nickel Alloys, Ann.	38	3
Monel, Ann.	37	13
Stainless Steels (cast), H & T	36	19
Platinum, Ann.	35	5
Cellulose Nitrate Film	35	5
Low Carbon Steel (HR)	35	4
Grade A Tin (CR)	35	—
Austenitic Chromium-Nickel Stainless Steels, CW	34	26
Cellophane	33	17
Vinylidene Chloride Film	33	7
Manganese Bronze, Ann.	33	—
Polyvinyl Butyral	32	28
Cellulose Acetate, Medium	32	15
Palladium, Ann.	32	8
Animal Fibers	31	19
Aluminum & Its Alloys, Ann.	31	14
Zinc Alloys (HR)	30	20
Columbium, Ann.	30	—
Soft Leads (sand cast)	30	—
Gold (cast)	30	—
Low Alloy Steels (61XX), Norm. (1600–1650 F)	29	6
Tin Bronze (cast), Leaded	28	12
Ethyl Cellulose Film	28	7
White Metal (CR)	28	—
Vanadium, Ann.	28	—
Zinc Alloys (CR)	27	17
Low Alloy Steels (86XX, 87XX), Ann.	27	5
Medium Carbon Steels (HR)	27	3
Low Alloy Steels (48XX), Ann.	27	1
Yellow Brasses (cast)	26	14
Low Carbon Steels, CW	26	9
Carbon Steel (cast), Ann.	26	6
Low Alloy Steels (23XX, 25XX), Ann.	26	5
Zirconium, Ann.	26	—
Acrylics, High Impact	>25	—
Monel (cast)	25	24
Tantalum, Ann.	25	15
Red Brass (cast), Leaded	25	10
Ferritic Stainless Steels, Ann.	25	5
Carbon Steels (cast), Norm. & T.	25	1
Martensitic Stainless Steels, Ann.	24	11
Mod Polystyrenes	23	22
Austenitic Nodular Irons	23	17
Cellulose Acetate, Hard	23	17
Low Alloy Steels (13XX), H & T.	23	5
Low Alloy Steels (cast), Norm. & T.	23	3
Low Alloy Steels (48XX), Norm.	23	2
High Alloy Steels (cast), Ann.	23	—
Nickel (cast)	22	8

[a] At room temperature.

continued on next page

Elongation[a]

Percent

Material ↓	Average	Range, ±
Vinylidene Chloride	22	8
Medium Carbon Steels, H & T (1000 F)	22	5
Aluminum Bronzes (sand cast)	21	14
Low Alloy Steels (23XX, 25XX), CD	21	4
Low Alloy Steels (43XX), Ann.	21	4
Low Alloy Steels (13XX), Ann.	21	3
Nickel Brasses & Bronzes (cast), Leaded	20	10
Nickel Silvers (sand cast)	20	10
Medium Carbon Steels, CW	20	6
Austenitic Chromium-Manganese Stainless Steels, CW	20	5
Ferritic Stainless Steels, CW	20	5
Hard Lead Alloys (chill cast)	20	4
Low Alloy Steels (92XX, 94XX), H & T (1200 F)	20	3
Carbon Steels (cast), H & T	20	—
Naval Brass, Half Hard	20	—
Low Expansion Nickel Alloys, CW	20	—
Copper, Half Hard	19	6
High Carbon Steels, Ann.	19	5
Monel, Ann. & Age H	19	5
Low Alloy Steels (40XX), CD & Ann.	19	3
Nitriding Steels, H & T (1200 F)	19	3
Manganese Bronze, Half Hard	19	2.4
Age Hardening Stainless Steels, Sol'n Tr	18	12
Titanium, Ann.	18	4
Aluminum & Its Alloys, H14	18	2
Standard Malleable Irons	17	8
Low Alloy Steels (61XX), H & T (300–1200 F)	17	5
Nitriding Steels, H & T (1250 F)	17	—
Martensitic Stainless Steels, H & T	16	14
Low Alloy Steels (86XX, 87XX), H & T (800 F)	16	5
Low Alloy Steels (46XX, 48XX), H & T (800 F)	16	2
Stainless Steels (cast), Ann.	16	2
Polyvinyl Chloride, Rigid	15	10
Polyvinyl Chloride Film, Rigid	15	10
Free-Cutting Steels, CD	15	5
Beryllium Coppers, CW	15	5
Titanium Alloys, Ann.	15	5
Semi-Red Brass (cast), Leaded	15	2
Acetal	15	—
Nitrided Steels, H & T	15	—
Leaded Naval Brass, Half Hard	15	—
Low Alloy Steels (40XX), H & T	14	7
Tin Bronze (cast), High Leaded	14	6
Age Hardening Stainless Steels, Aged	14	4
Wrought Iron	14	—
Tin-Base Babbitts (die cast)	13	9
Aluminum & Its Alloys, Half Hard	13	7
Chromium-Molybdenum Steels, H & T (800 F)	13	3
Low Alloy Steels (43XX), H & T (800 F)	13	1
Uranium	13	—
Nodular & Ingot Irons	12	12
Low Alloy Steels (92XX, 94XX), H & T (800 F)	12	30
Low Alloy Steels (cast), H & T	12	8
High Carbon Steels, H & T	12	2
Aluminum & Its Alloys, Hard	11	9
Magnesium Alloys (forged)	11	4
Magnesium Alloys (cast), Sol'n Tr	11	1
Inconel (cast)	10	9
Aluminum Bronzes (sand cast), H & T (1000–1150 F)	10	5
Duranickel, Age H	10	5
Phosphor Bronzes, Hard	10	3
Muntz Metal, Half Hard	10	—
Titanium Alloys, Ht Tr	9	6
Stainless Steels (cast)	8.5	6.5
Zinc Alloys (die cast)	8.5	1.5
Cartridge Brass, 70%, Hard	8	—
Yellow Brass, Hard	8	—
Pearlitic Malleable Irons	7.5	4.5
Beryllium Coppers, Ann. & Ht Tr	7.5	4.5
Monel, Age H	7.5	2.5
Nylon, Glass Fiber-Filled	7.5	1.0
Magnesium Alloys (cast)	7	5
Copper, Hard	7	1
Low Brass, 80%, Hard	7	—
Cobalt, Ann.	6.5	6.5
Polystyrene Film	6.5	2.5
Zirconium (CW)	5.7	4.3
Molybdenum (sintered), Ann.	5.5	1.5
Aluminum Alloys (cast)	5.3	3.7
Cobalt, CW	5	3
Beryllium Copper, CW & Ht Tr	5	3
Lead-Base Babbitts (chill cast)	5	3
Gilding, 95%, Hard	5	—
Commercial Bronze, 90%, Hard	5	—
Red Brass, 85%, Hard	5	—
Polyesters (cast), Rigid	5	—
Columbium, CW	5	—
Acrylics, GP	4.5	2.5
Bast Fibers	4	2
High Alloy Steels (cast), Aged 48 Hr (1800 F)	4	—
Gold, CW	4	—
Beryllium	3.5	1.5
Hard Rubber, GP	3	1
Platinum, CW	3.0	0.5
Magnesium Alloys (cast), Sol'n Tr & Aged	3	2
Vanadium, CW	3	—
Aluminum Alloys (cast), Sol'n Tr & Aged	2.8	2.2
Glass Fiber	2.8	0.9
Hard Rubber, Chem Res	2.7	—
Hard Rubber, High Ht Res	2.6	—
Hard Rubber, High Dielec Str	2.6	—
Inconel (cast), Ann. & Aged	2.5	1.5
Monel (cast), Ann. & Aged	2.5	1.5
Nickel Silvers, Extra Hard	2.5	0.5
Hard Fibers	2.5	0.5
Silver, CW	2.5	—
Methylstyrenes	3.6	1.4
Cobalt (cast)	2	2
Haynes Stellite 21, Aged (1300 F)	2	—
Hard Rubber, Low Moisture Abs	1.8	—
Polystyrenes	1.7	0.7
Rubber Phenolics	1.5	0.8
Paladium, CW	1.5	—
Tantalum, CW	1.2	0.3
Tungsten, CW	1	1
Zinc Alloys (chill cast)	1	—
Ureas	1	—
Hard Rubber, High Arc Res	1	—
Melamines, Filled	0.55	0.25
Phenolics	0.45	0.35

Hardness of Nonmetallics (exc Plastics & Rubber)

Knoop

Material ⬇	Average	Range, ±
Diamond	7000	—
Cubic Boron Nitride	7000	—
Boron Carbide	2800	—
Titanium Boride	2720	—
Silicon Carbide	2500	—
Titanium Carbide	2460	—
Beryllium Carbide	2300	—
Zirconium Carbide	2090	—
Tantalum Carbide	2050	—
High Alumina Ceramics	2000	—
Columbium Carbide	1880	—
Tungsten Carbide	1880	—
Cemented Carbides	1600	200
Alumina Elec Ceramics	1600	150
Zirconium Boride	1560	—
Chromium Carbide	1300	—
Beryllia	1220	—
Electrical Ceramics	1100	300
Molybdenum Disilicide	960	100
Quartz	800	—
Polycrystalline Glass	700	4
Glasses	400	100
Mica, Synthetic	200	—
Calcite	130	—
Mica, Natural	90	—
Gypsum	30	—

Hardness of Metals

Brinell

Material ⬇	Average	Range, ±
Low Alloy Steels (13XX), H & T (800 F)	450	63
Low Alloy Steels (43XX), H & T (800 F)	440	5
Stainless Steels (cast), H & T	430	40
Tungsten, CW	430	40
Low Alloy Steels (41XX), H & T (800 F)	410	35
Nitrided Steels, H & T	410	—
Low Alloy Steels (46XX, 48XX), H & T (800 F)	395	5
Martensitic Stainless Steels, H & T	380	200
Low Alloy Steels (40XX), H & T (1000 F)	380	150
Low Alloy Steels (61XX), H & T (1200 F)	380	66
Age Hardening Stainless Steels, Aged	350	40
High Carbon Steels, H & T (700 F)	350	40
Osmium (cast)	350	—
Iridium, CW	350	—
Inconel (cast), Ann. & Aged	340	40
Monel (cast), Ann. & Aged	340	40
Duranickel, Age H	340	40
Titanium Alloys, Ann.	340	40
Age Hardening Stainless Steels, Sol'n Tr	340	40
Low Alloy Steels (86XX, 87XX), H & T (800 F)	330	89
Low Alloy Steels (cast), H & T	320	82
Rhodium, CW	320	65
Monel, Age H	320	30
Nitriding Steels, H & T (1200 F)	290	32
High Carbon Steels (HR)	260	29
Austenitic Stainless Steels, CW	240	—
Gray Irons	230	65
High Alloy Steels (cast), Aged 24 Hr (1400 F)	230	42
Nickel Steels, CD	230	29
Nodular Irons	220	80
Ruthenium	220	—
Low Alloy Steels (43XX), Ann.	210	27
Medium Carbon Steels, H & T (1000 F)	210	3
Martensitic Stainless Steels, Ann.	200	55
Manganese Steels, Ann.	200	22
Medium Carbon Steels, CW	200	19
High Carbon Steels, Ann.	200	19
Cast Stainless Steels, Ann.	200	8
Low Alloy Steels (48XX), Ann.	196	4
Copper, Hard	194	—
Free-Cutting Steels, CD	190	40
Nickel Steels (HR)	190	35
High Alloy Steels (cast)	190	29
Medium Carbon Steels (HR)	190	24
Low Alloy Steels (86XX, 87XX), Ann.	190	23
Stainless Steels (cast)	190	21
Low Alloy Steels (23XX, 25XX), Ann.	180	29
High Alloy Steels (cast), Ann.	180	—
Nickel, CD	175	50
Pearlitic Malleable Irons	170	12
Carbon Steels (cast), Norm. & T	170	7
Iridium, Ann.	170	—
Aluminum Bronzes (sand cast)	160	37
Ferritic Stainless Steels, Ann.	160	30
Low Expansion Nickel Alloys, Ann.	160	13
Iridium (cast)	160	—
Yellow Brass, Hard	160	—
Manganese Bronze, Half Hard	160	—
Zirconium, Ann.	160	—
Cartridge Brass, 70%, Hard	154	—
Austenitic Stainless Steels, Ann.	153	7
Muntz Metal, Hard	151	—
Yellow Brass (cast), High Strength	150	70
Aluminum-Zinc Alloys (cast), T6	147	3
Low Carbon Steels, CW	140	25
Ingot Iron, CD	140	—
Naval Brass, Hard	140	10
Vanadium, Ann.	140	—
Yellow Brass, Hard	140	—
Standard Malleable Irons	130	17
Cobalt, Ann.	130	8

continued on next page

Hardness of Metals

Brinell

Material ↓	Average	Range, ±
Low Brass, 80%, Hard	130	—
Hafnium, Ann.	130	—
Red Brass, 85%, Hard	126	—
Low Carbon Steels (HR)	120	21
Cobalt (cast)	120	15
Carbon Steels (cast), Ann.	120	—
Aluminum Alloys (cast), Sol'n Tr & Aged	115	25
Aluminum & Its Alloys, T6	112	38
Austenitic Stainless Steels, Ann.	110	35
Nickel (cast)	110	20
Palladium, CW	110	—
Commercial Bronze, 90%, Hard	107	—
Nickel, Ann.	105	15
Gilding, 95%, Hard	105	—
Wrought Iron (HR)	101	4
Nickel Silvers (sand cast)	100	50
Rhodium, Ann.	100	50
Aluminum & Its Alloys, T72	95	—
Zinc Alloys (die cast)	86	4
Ingot Iron (HR)	83	—
Muntz Metal, Ann.	82	—
Aluminum & Its Alloys, Hard	74	30
Tin Bronze (cast), Leaded	70	10
Zinc Alloys, (CR)	70	10
Low-Expansion Nickel Alloys, Ann.	70	2
Columbium, Ann.	70	—
Ingot Iron, Ann.	69	—
Aluminum-Zinc Alloys (cast)	60	—
Yellow Brass (cast), Leaded	58	18
Magnesium Alloys (forged)	58	11
Red & Semi-Red Brass (cast) Leaded	58	8
Gold, CW	58	—
Magnesium Alloys (cast), Sol'n Tr	57	6
Zinc Alloys (HR)	56	5
Platinum, CW	55	42
Magnesium Alloys (cast)	54	21
Tin Bronze (cast), High Leaded	53	18
Aluminum & Its Alloys, Ann.	49	26
Palladium, Ann.	46	—
Platinum, Ann.	45	7
Zinc (HR)	42	5
Silver (cast)	42	—
Copper, Ann.	40	—
Aluminum Alloys (cast)	40	30
Gold (cast)	33	—
Silver, Ann.	30	5
Gold, Ann.	25	—
Pewter (cast)	23	—
Aluminum-Magnesium-Silicon Alloys (cast)	22	8
Tin-Base Babbitts (chill cast)	22	5
Lead-Base Babbitts (chill cast)	21	7
White Metal (cast)	20	—
White Metal, Ann.	17	—
Pewter, Ann.	13	—
Hard Lead Alloys (chill cast)	11.2	4.2
Hard Lead Alloys (rolled)	7.7	1.8
Grade A Tin, Ann.	7	—
Tellurium Lead (extr)	6	—
Soft Lead (chill cast)	4.2	—

Hardness of Plastics and Rubber[a]

Material ↓	Average	Range, ±
ROCKWELL M HARDNESS		
Urea	M118	2
Melamines	M117	8
Phenolics, GP	M114	6
Epoxies	M110	—
Phenolics (cast), Mech & Chem	M106	14
Phenolics, Shock & Ht Res	M106	14
Allyls (cast)	M105	13
Phenolics, Elec	M105	5
Diallyl Phthalate	M104	4
Plastics Laminates	M98	23
Epoxies (cast)	M93	17
Acrylics	M91	12
Polyesters (cast), Rigid	M90	25
Nylons, Glass Fiber-Filled	M90	5
Silicone Plastics, GP	M89	—
Polystyrene, Glass Fiber-Filled	M85	5
Polyvinyl Formal	M85	—
Methylstyrene-Acrylonitrile	M83	—
Polymethylstyrene	M81	5
Polystyrenes, GP	M74	6
Rubber Phenolics	M65	25
Vinylidene Chloride	M57	8
Mod Polystyrenes, Impact Res	M48	32
Silicone Plastics, Impact Res	M45	—
ROCKWELL R HARDNESS		
Acetal	R120	—
Polyvinyl Chloride, Rigid	R118	2
Polycarbonate	R118	—
CFE Fluorocarbons	R112	3
Nylons	R111	7
Phenolics (cast), Transparent	R109	11
Cellulose Nitrate Sheet	R105	10
ABS Resins, Impact Res	R102	16
Chlorinated Polyether	R100	—
Ethyl Cellulose	R95	25
Polypropylene	R90	5
Cellulose Acetate	R86	37
Cellulose Propionate	R70	50
Polyethylenes	R40	10
DUROMETER A HARDNESS		
Hard Rubber, High Ht Res	A89	3
Hard Rubber, GP	A82	5
Polyvinyl Chloride, Nonrigid	A75	25
Viton Rubber	A75	15
Styrene-Butadiene Rubber	A65	25
Butyl Rubber	A65	25
Natural Rubber	A60	30
Polyvinyl Alcohol	A55	45

[a] No relationship between different scales is implied.

Impact Strength of Metals

Notched Izod, ft-lb[a]

Material	Average	Range, ±
Austenitic Stainless Steels, Ann.	123	42
Cobalt Alloys	120	—
Low Alloy Steels (86XX, 87XX), H & T (1200 F)	87	18
Low Alloy Steels (51XX), H & T (1200 F)	78	—
Low Alloy Steels (41XX), H & T (1200 F)	77	23
Low Alloy Steels (23XX, 25XX), H & T	75	20
Low Alloy Steels (43XX), H & T (1200 F)	74	1
Martensitic Stainless Steels, Ann.	70	20
Low Alloy Steels (61XX), Norm.	67	35
Nitriding Steels, H & T (1200 F)	65	—
Low Alloy Steels (92XX, 94XX), H & T (1200 F)	61	38
Low Alloy Steels (46XX, 48XX), H & T (1200 F)	60	—
Low Alloy Steels (13XX), Ann.	52	—
Low Alloy Steels (61XX), H & T	50	37
Low Alloy Steels (48XX), H & T	36	8
Carbon Steels (cast), Ann.	30	—
Low Alloy Steels (92XX, 94XX), Norm.	27	21

Material	Average	Range, ±
Stainless Steels (cast)	24	22
Yellow Brass (cast), High Strength	24	16
White Metal (cast)	22	—
Carbon Steels (cast), Norm. & T	20	—
Ferritic Stainless Steels, Ann.	14	11
High Carbon Steels, Ann.	14	8
Tin (cast)	14	—
High Carbon Steels, H & T	13.5	8.5
Tin Bronzes (cast), Leaded	12	4
High Carbon Steels, HR	11	7
Red & Semi-Red Brasses (cast), Leaded	9	3
Magnesium Alloys (cast)	5	4
Tin Bronzes (cast), High-Leaded	5	3
Magnesium Alloys, Sol'n Tr	4.5	0.5
Magnesium-Thorium & Magnesium-Zirconium Alloys (forged)	4	1
Magnesium-Thorium & Magnesium-Zirconium Alloys (sand cast)	2.3	0.7
Lead-Tin-Antimony (chill cast)	1.8	0.7
Magnesium Alloys (cast), Sol'n Tr	1.5	0.5

[a] Values in this table are not directly comparable to those for Plastics (below) because the methods of computing test results differ.

Impact Strength of Plastics

Notched Izod, ft-lb/in.

Material	Average	Range, ±
Phenolics, Very High Shock Res	22	11
Nylon, Soluble	>16	—
Polycarbonate	14	2
Plastics Laminates, Low Pressure	13	5
Polyvinyl Formal	10	10
Plastics Laminates, Elec	10	4
Alkyds, High Str	10	2
Mod Polystyrene, Extra High Impact	8.5	2.5
Melamines, Glass Fiber-Filled	8	4
Plastics Laminates, GP	7.7	6.7
Polyethylene, High Density	7.2	6.8
Polyesters (cast), Nonrigid	>7	—
Cellulose Nitrate	6	1
Cellulose Propionate	5.9	5.1
ABS Resins	5.3	4.7
Ethyl Cellulose, High Impact	5.3	1.7
Vinylidene Chloride	5	3
Diallyl Phthalate, Glass Fiber-Filled	4.8	4.2
Silicones, High Impact	4.5	1.5
Phenolics, High Shock Res	4.3	3.7
Cellulose Acetate Butyrate, Soft	4.0	1.4
Ethyl Cellulose, GP	3.9	2.1
Cellulose Acetate, Soft	3.6	1.6
CFE Fluorocarbons	3.6	—
TFE Fluorocarbons	3.3	0.7
Polystyrene, Glass Fiber-Filled	3.2	1.8
Diallyl Phthalate, Dacron-Filled	3.1	1.4
Nylons 6 & 11	2.4	1.2
Mod Polystyrene, High Impact	2	1
Nylon, Glass Fiber-Filled	2	—

Material	Average	Range, ±
Phenolics, Shock & Ht Res	1.9	1.6
Plastics Laminates, Mech	1.6	1.4
Cellulose Acetate, Hard	1.5	1.1
Cellulose Acetate Butyrate, Hard	1.5	0.9
Acrylics, High Impact	1.4	0.6
Acetal	1.4	—
Nylons 66 & 610	1.3	0.7
Melamines, Intermed Shock Res	1.3	0.2
Polypropylene	1	—
Polyvinyl Butyral	0.93	0.19
Epoxies	0.85	0.65
Diallyl Phthalate, Orlon-Filled	0.85	0.35
Polyvinylchlorides	0.73	0.47
Melamines, Low Shock Res	0.7	0.2
Hard Rubber	0.40	0.13
Acrylics, GP	0.4	0.1
Methylstyrene Acrylonitrile	0.40	—
Mod Polystyrene, Ht & Chem Res	0.38	0.12
Diallyl Phthalate, Asbestos-Filled	0.38	0.07
Phenolics, GP	0.37	0.13
Phenolics (cast)	0.34	0.11
Alkyds, GP	0.33	0.02
Polymethylstyrene	0.33	—
Melamines, GP	0.32	0.08
Silicons, GP	0.32	0.06
Polystyrene, GP	0.30	0.05
Ureas	0.30	0.05
Polyesters (cast), Rigid	0.29	0.11
Allyls (cast)	0.25	0.07
Vinylidene Chloride, Oriented	0.05	—

Yield Strength of Metals[a]

1000 psi

Material	Average	Range, ±
Low Alloy Steels (92XX, 94XX), H & T (800 F)	203	23
Low Alloy Steels (43XX), H & T (1200 F)	195	5
Low Alloy Steels (41XX), H & T (800 F)	193	23
Titanium Alloys, Ht Tr	178	42
Low Alloy Steels (61XX), H & T (1000 F)	174	5
Low Alloy Steels (46XX, 48XX), H & T (800 F)	170	10
Martensitic Stainless Steels, H & T	168	167
Titanium Alloys, Ann	155	97
Age Hardening Stainless Steels, Aged	150	50
Yellow Brass (cast), High Strength	150	70
Low Alloy Steels (86XX, 87XX), H & T (800 F)	146	48
Beryllium Copper, Hard	140	10
Low Alloy Steels (61XX), H & T (1200 F)	134	4
Nitriding Steels, H & T	132	48
High Carbon Steels, H & T (700 F)	124	18
Stainless Steels (cast), H & T	116	49
Vanadium, CW	109	—
Nickel Brass & Bronze (cast), Leaded	100	50
Austenitic Chromium-Manganese Stainless Steels, CW	92.5	17.5
Low Alloy Steels (43XX), Ann	88	11
Nickel Silvers, Hard	88	10
Low Alloy Steels (23XX, 25XX), H & T (1000 F)	86	14
Phosphor Bronze, Grade A Hard	85	8
Titanium, Ann	81	1
Medium Carbon Steels, CW	81	9
Free-Cutting Steels, CD	80	10
Nodular Iron	78.5	46.5
Cupro Nickels, Hard	77	2
Cartridge Brass, Hard	75	—
Cobalt Alloys, Ann	75	10
Silicon Bronze, Type B Hard	75	—
High Carbon Steels (HR)	74.5	9.5
Naval Brass, Hard	73.5	13.5
Red Brass, Hard	72	—
Aluminum-Zinc Alloys, T6	71	2
Phosphor Bronze, Grade D, CR	70.4	—
Low Alloy Steel (61XX), Norm	69	19
Low Brass, Hard	68	—
Muntz Metal, Hard	66	—
Martensitic Stainless Steels, Ann	65	40
Yellow Brass, Hard	65	—
Manganese Bronze, Hard	65	—
Vanadium, Ann	64	—
Commercial Bronze, Hard	63	—
Heat Resistant Alloys, H & T (1400 F)	62.5	17.5
Ferritic Stainless Steels, CW	62.5	17.5
Nickel Steels (HR)	62.5	7.5
Stainless Steels (cast), Ann	62.5	2.5
Zirconium, CW	61	3
Low Alloy Steels (86XX, 87XX), Ann	60.5	9.5
High Carbon Steels, Ann	59	7
Nickel Steels, Ann	59	6
Yellow Brass (cast), Leaded	58	18
Gilding Metal, Hard	57	3
Heat Resistant Alloys (cast)	55.5	19.5
Inconel X, Ann	55	10
Phosphor Bronze, Grade E, CR	54.8	—
Medium Carbon Steels (HR)	54.5	4.5
Austenitic Chromium-Manganese Stainless Steels, Ann	54	1
Aluminum & Its Alloys, T6	52	21
Stainless Steels (cast), Ht Tr	52	21
Low Carbon Steels, CW	51.5	18.5
Malleable Iron	51	19
Beryllium	50	5
Coppers, Hard	50.5	3.5
Duranickel, Ann	47.5	12.5
Ferritic Stainless Steels, Ann	45	10
Silver, CW	44	—
Cobalt, Ann	42.5	22.5
Low Carbon Steels, HR	38.5	9.5
Monel (cast)	38.5	6.5
Cartridge Brass, Ann	38	—
Inconel, Ann	37.5	7.5
Aluminum-Magnesium-Silicon Alloys, T6	36	4
Monel, Ann	35	10
Austenitic Chromium-Nickel Stainless Steels, Ann	35	
Aluminum Alloys (cast), Sol'n Tr & Aged	34	5 8
Cobalt (cast)	31.5	11.5
Beryllium Copper, Ann	30	5
Gold & Palladium, CW	30	—
Magnesium Alloys (extr)	28.5	6.5
Thorium, Ann	27	—
Platinum, CW	27	—
Naval Brass, Leaded Ann	25	—
Uranium, Ann	25	—
Zirconium, Ann	24.5	13.5
Nickel (cast)	22.5	7.5
Medium Carbon Steels, H & T (1000 F)	22.5	4.5
Muntz Metal, Ann	22	—
Nickel, Ann	21	9
Magnesium Alloys (cast), Sol'n Tr & Aged	20.5	1.5
Naval Brass, Ann	20.5	0.5
Phosphor Bronze, Grade A Ann	18.5	0.5
Aluminum Alloys (cast)	18	9
Nickel Silvers, Ann	17.2	2.5
Cupro Nickels, Ann	17	3
Aluminum-Zinc Alloys, Ann	15	—
Magnesium-Thorium-Zirconium Alloys (cast)	14.5	0.5
Magnesium Alloys (cast)	14	9
Red Brass, Ann	14	—
Admiralty Metal, Ann	13.5	0.5
Magnesium Alloys (cast), Sol'n Tr	13.5	0.5
Aluminum & Its Alloys, Ann	13	9
Yellow Brass, Ann	13	—
Commercial Bronze, Ann	11	—
Gilding Metal, Ann	10.5	2.5
Silver, Ann	8	—
Aluminum-Magnesium-Silicon Alloys, Ann	7.5	0.5
Coppers, Ann	6.5	0.5
Palladium, Ann	5	—
Silver (cast)	5	—
Tin and Its Alloys (CR)	4	2
Platinum, Ann	3.8	1.7
Tin, Ann	1.3	—

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[a] 0.2% offset.

Creep Strength of Metals

Material	Form, Condition	Stress (1000 psi) for 0.01% Creep per 1000 Hr at Indicated Temp (F)					Stress (1000 psi) for 0.1% Creep per 1000 Hr at Indicated Temp (F)				
Up to 800 F		300	400	500	600	800	300	400	500	600	800
NONFERROUS METALS											
Coppers	Wrought (annealed)	3–8	1.5–5	0.4–2.6	—	—	—	—	—	—	—
Nonleaded Brasses	Wrought (annealed)	0.9–19	2–11	0.3–23	—	—	25	5–9	1–2	—	—
Bronzes	Wrought (annealed)	14–23	5–10	2–5	—	—	—	—	—	—	—
Cupro-Nickel	Wrought (water quenched, aged)	25–40	15–30	8–30	—	—	—	22	13	—	—
Aluminum 2024-T	Sheet	52	44	—	—	—	—	—	—	—	—
Aluminum 7075-T	Sheet	50	30	—	—	—	—	—	—	—	—
Titanium (commercial)	Sheet (annealed)	—	38	—	32	10	—	—	—	—	—
Above 800 F		1000	1100	1200	1500	1600	1000	1100	1200	1500	1600
CARBON AND LOW ALLOY STEELS											
Low Carbon Steel	Wrought, Cast	1.8	—	0.1	—	—	3.3–5	—	0.5	—	—
Carbon-Molybdenum Steels	Wrought, Cast	5–7	3	1	—	—	10–12	4	2	—	—
Chromium-Molybdenum Steels (0.5–3%)	Wrought, Cast	6–12	2–4	1–2.5	—	—	10–20	3–8	2–4.5	—	—
Chromium Steels											
4–6%	Wrought, Cast	6–7	2.5–3.5	1–2	—	—	8–11	5–6.5	2–3.5	—	—
6–10%	Wrought, Cast	5–9	2.5–4	1–2	—	—	8–12	4–6	2.5–3	—	—
STAINLESS STEELS											
Martensitic Chromium Steels (403, 410, 416, 420)	Wrought	8	3.5	1.3	—	—	9.2	4.2	2	—	—
Ferritic Chromium Steels (405, 430, 440)	Wrought	4.2–7	2.3–4.5	1.0–1.6	—	—	6–8.5	3–5	1.5–2.2	—	—
Nickel-Chromium Steels											
304, 316, 321, 347	Wrought	12–17	7.5–11.5	4.5–7	1–2	—	17–25	12–18.2	7–12.7	1.2–2.8	—
309	Wrought	—	—	4	0.5	—	15.9	11.6	8	1.0	—
310, 314	Wrought	17	13	8	2	—	17	13–14	9	1–2.5	—
CORROSION RESISTANT CASTING ALLOYS											
Iron-Chromium Alloys (HC, HD)	Cast	—	—	—	—	—	—	—	—	1.2–3.5[a]	0.7–1.9
Iron-Chromium-Nickel Alloys (HE, HF, HH, HI, HK, HL)	Cast	—	—	—	—	—	—	—	—	3.5–7[a]	2–4.3
Nickel-Chromium Alloys (HT, HU, HW, HX)	Cast	—	—	—	—	—	—	—	—	6–8.5[a]	3–5
HIGH TEMPERATURE ALLOYS											
Inconel X		—	—	—	—	—	—	—	64	12.3	9.0
19-9 DL		—	—	—	—	—	—	—	20	7.1	—
Hastelloy X		—	—	—	—	—	—	—	—	—	2.4
N 155		—	—	—	—	—	—	—	18.4[b]	10.3	—
S-816		—	—	—	—	—	—	—	42	11.5	5.8

[a] At 1400 F. [b] At 1350 F.

Stress-Rupture Strength of Metals

Material ↓	Form, Condition	Stress (1000 psi) for Rupture in **100 Hr** at Indicated Temp (F)					Stress (1000 psi) for Rupture in **1000 Hr** at Indicated Temp (F)				
Up to 800 F		300	400	500	600	800	300	400	500	600	800
NONFERROUS METALS											
Coppers	Wrought (annealed)	22–25	20–24	—	—	—	19–21	15–19	—	—	—
Nonleaded Brasses	Wrought (annealed)	34–50	26–35	—	—	—	28–46	18–25	—	—	—
Bronzes	Wrought (annealed)	57	36	—	—	—	50	30	—	—	—
Aluminum Alloys											
2024–T	Sheet	—	—	—	—	—	37	19	—	—	—
7075–T	Sheet	—	—	—	—	—	20	9	—	—	—
Titanium (commercial)	Sheet (annealed)	—	45	—	—	20	—	44	—	32	16
Titanium Alloys											
4 Al–4 Mn		—	—	—	—	—	—	110	—	95	46
5 Al–2.5 Sn		—	—	—	—	—	—	76	—	65	58
8 Mn		—	—	—	—	—	—	100	—	91	26
Above 800 F		1000	1200	1400	1500	1600	1000	1200	1400	1500	1600
CARBON AND LOW ALLOY STEELS											
Low Carbon Steel	Wrought, Cast	15	5	1.5	—	—	10	2.8	0.7	—	—
Carbon–Molybdenum Steel (0.5% Mo)	Wrought	32–37	8	—	—	—	—	—	—	—	—
Chromium–Molybdenum Steels (0.5–3%)	Wrought	28–40	10–13	—	—	—	24–39	4–8	0.5–1.0	—	—
Chromium Steels											
4–6%	Wrought	23–30	4–9	2–3	1.5–2	—	18–20	5–7	1.8–2	0.7–1	—
6–10%	Wrought	—	10	3	2	—	—	6	2	1	—
STAINLESS STEELS											
Martensitic Chromium Steels (403, 410, 416, 420)	Wrought	—	—	—	—	—	13[a]	3[a]	—	—	—
Ferritic Chromium Steels (405, 430, 446)	Wrought	—	—	—	—	—	13[a]	3[a]	—	—	—
Nickel–Chromium Steels											
304, 316, 321, 347	Wrought	48–55	22–29	—	6–7	—	38–40	18–22	—	3.8–4.4	—
309	Wrought	—	28	—	8.5	—	—	20	—	4.8	—
310, 314	Wrought	38	28	—	11	—	30	18	—	5	—
CORROSION RESISTANT CASTING ALLOYS											
Iron-Chromium Alloys (HC, HD)	Cast	—	—	3–10	—	1.5–5	—	—	2	—	1.2
Iron–Chromium–Nickel Alloys (HE, HF, HH, HI, HK, HL)	Cast	—	30–35	10–15	—	5–9	—	17–22	8–10	—	3.5–5
Nickel–Chromium Alloys (HT, HU, HW, HX)	Cast	—	—	10–18	—	6–8.5	—	—	7.5–12.5	—	4–7
HIGH TEMPERATURE ALLOYS											
Inconel X		115	80	42	30	11	110	55	33	18.5	6.6
19–9 DL		—	60	28	13	—	—	40	16.5	10.5	—
Hastelloy C		—	53	—	15	—	—	35	—	9.5	—
Hastelloy X		—	45	21	14	8	—	30	16	10	6
N–155		—	60	25.7	20	15	—	46	19.5	15	—
S–816		—	62	32	29	15	—	50	27	22	10
L605		—	45	30	22	15	—	—	23	18	11

[a] 10,000 hr.

Effect of Radiation on Metals

EFFECT ON HARDNESS

Material			Radiation Exposure[a]	Change in Brinell Hardness
Type	Condition	Initial Brinell Hardness		
CARBON STEELS				
1018	Annealed	174	1	+9
		156		+12
	Hardened	241	1	+6
	Annealed	138	2	+23
	Hardened	237		+6
1042	Annealed	201	1	+6
		236		+34
	Hardened	430	1	+14
	Annealed	225	2	−38[b]
	Hardened	390		+36
1045	Annealed	187	3	0
	Hardened	514		−144[c]
1095	Annealed	297	1	+14
	Hardened	542		+8
	Annealed	290	2	+25
	Hardened	535		0
1113	Annealed	195	1	+22
	Hardened	190		+5
1141	Annealed	220	1	+35
	Hardened	421		+9
STAINLESS STEELS				
304	Annealed	131	4	0
	Malcomized	654	5	+156
309	Annealed	152	4	+6
316	Annealed	143	4	0
	Annealed	154	5	+74
	Cold Worked	226		+59
329	Annealed	158	6	0
347	Annealed	152	4	0
	Annealed	183	6	0
	Malcomized	656	7	0
347 (Cb+Ta)	Annealed	153	6	+22
	Shot Peened	153		+15
410	Malcomized	656	5	+84
		688	7	0
		739	8	0
431	Annealed	277	6	+54
	Hardened	371		+29
440C	Hardened	545	5	0
		461	8	+73
		388		+27
	Malcomized	577	7	+223
442	Annealed	185	6	+38
	Hardened	200		+50
17-4PH	Annealed	315	6	+162
	Hardened	415	6	+35
		403	9	+29
		477		0
	Malcomized	740	6	+80
NICKEL AND ITS ALLOYS				
Nickel A	Annealed	64	10	+73
Hastelloy C	Cast	228	11	+132
		170		+58
	Wrought	255	10	+30
		209	12	0
		256	13	+19
Monel	Annealed	150	12	+59
		157	13	+23
K Monel	As Received	260	12	+25
		255	13	+10
	Annealed	148	6	+32
	Hardened	341		0
Inconel	As Received	175	12	+65
		180	13	+48
Inconel X	Annealed	209	12	+56
		219	13	+28

[a] 1 = nvt (integrated thermal flux-product of flux and exposure time) of 1 x 10^{19} slow at 450-500 F.
2 = nvt of 2 x 10^{19} slow and 7 x 10^{18} fast at 70-140 F
3 = nvt of 3 x 10^{20} slow and 1 x 10^{20} fast at 70-80 F.
4 = nvt of 1.2 x 10^{19} slow in 400-500 F flewing water.
5 = nvt of 3.7 x 10^{20} slow and 5.1 x 10^{20} fast at 70-80 F.
6 = nvt of 3 x 10^{19} slow in 540 F flowing water.
7 = nvt of 10^{19} slow; dry exposure.
8 = nvt of 5 x 10^{19} slow and 4 x 10^{19} fast.
9 = nvt of 4.4 x 10^{19} slow in 540 F flowing water.
10 = nvt of 1 x 10^{19} slow in 400-500 F flowing water.
11 = nvt of 4 x 10^{19} slow and 5 x 10^{19} fast.
12 = nvt of 5 x 10^{19} slow and 4 x 10^{19} fast at 70-140 F.
13 = nvt of 4 x 10^{19} slow in 540 F flowing water.

[b] No explanation for decrease in hardness values.

[c] Decrease in hardness due to corrosion products caused by leaking container.

EFFECT ON TENSILE PROPERTIES

Material					Radiation Exposure[a]	Chg in Properties After Irradiation	
Type	Condition		Ten Str, 1000 psi	Elong (2 in.), %		Ten Str, 1000 psi	Elong, %
STAINLESS STEELS							
304	Annealed	[b]	92	71	1	+1	−21
309	Annealed	[b]	95	54	1	+4	−3
316	Annealed	[b]	90	70	1	−1	−3
347	Annealed	[b]	99	56	1	+4	−2
316	Annealed	[c]	79	—	2	+71	—
410	Malcomized	[c]	69	—	3	+3	—
440C	Hardened	[c]	205	—	3	+35	—
NICKEL AND ITS ALLOYS							
Nickel	Wrought	[b]	65	45	1	+4	−11
Monel	As Received	[d]	129	—	4	+4	—
		[e]	86	32		+5	−3
		[e]	85	33	5	+11	−23
K Monel	As Received	[d]	210	—	4	−15	—
		[e]	125	10		+8	+9
		[d]	211	—	5	+15	—
		[e]	123	11		+11	−8
Inconel	As Received	[d]	150	—	4	+10	—
		[e]	107	30		+6	−1
		[d]	151	—	5	+21	—
		[e]	106	31		+10	−2
Inconel X	As Received	[d]	174	—	4	+24	—
		[e]	128	36		+11	−1
		[d]	174	—	5	+29	—
		[e]	126	37		+7	−14
Hastelloy C	Cast	[e]	80	—	3	+27	—
	Wrought	[b]	139	53	1	+3	−11
		[d]	198	—	4	−7	—
		[e]	140	20	4	−3	+16
		[e]	138	20	5	+4	−8
		[d]	198	—		+22	—
HIGH DENSITY MATERIALS							
Tantalloy	As Received		136	29	6	+29	−15
Tungsten			152	0	6	−35	0
Tantalum			68	21	6	+18	−4
Tantung G			72	5	6	−3	−1

[a] 1 = nvt of 1 x 10^{19} slow in 400-500 F flowing water.
2 = nvt of 3.7 x 10^{20} slow and 5.1 x 10^{20} fast at 70-80 F.
3 = nvt of 4 x 10^{19} fast.
4 = nvt of 4 x 10^{19} slow in 540 F flowing water.
5 = nvt of 5 x 10^{19} slow and 4 x 10^{19} fast in cooling water at 70-140 F.
6 = nvt of 1 x 10^{19} slow and 5 x 10^{19} fast (estimated).

[b] Flat specimens. [c] Subsize round specimens. [d] Notched specimens.

[e] Unnotched specimens.

EFFECT ON DENSITY[a]

Material		Avg Chg in Density After Irradiation, %
Type	Initial Density, lb/in.	
Stainless Steels		
316	7.995	−0.06
347	7.938	−0.09
347+Ta	7.942	−0.04
410	7.675	−0.05
Nickel A	8.894	−0.07
Monel	8.836	−0.05
Cobalt Alloys		
Stellite 3	8.550	+0.06
Stellite 6	8.330	+0.11
Carbon Steel (SA-212)	7.850	0

[a] Radiation exposure: nvt of 2 x 10^{20} slow and 3.5 x 10^{19} fast at 70-140 F.

EFFECT ON ELECTRICAL RESISTIVITY

Material		Avg Chg in Elec Res After Irradiation
Type	Initial Elec Res	
Stainless Steels		
304	80 (28.0 C)	+0.2 (27.8 C)
309	79 (27.5 C)	−2.1 (27.0 C)
316	77 (28.4 C)	+1.01 (28.4 C)
347	75 (26.2 C)	+0.44 (27.3 C)
Nickel A	9 (27.0 C)	−0.17 (27.2 C)
Hastelloy C	126 (26.2 C)	+7.30 (27.8 C)

Sources of Data

Many of the compilations in this issue are entirely new. Others have been published previously in this magazine, particularly in the 1958-59 *Materials Selector.* Collecting new data and up-dating old compilations required the aid of many organizations. We gratefully acknowledge their assistance. Although it would be impractical to list all who contributed in one way or another, we acknowledge particularly the assistance of the following:

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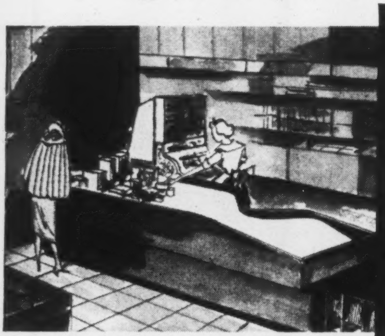
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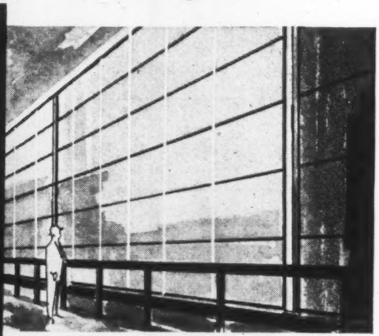
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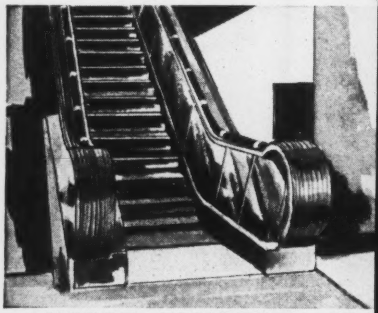
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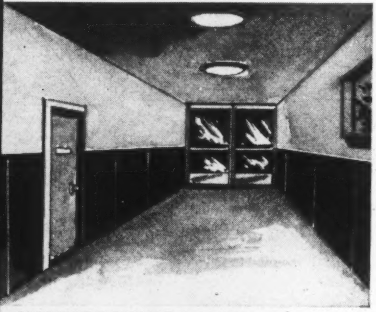
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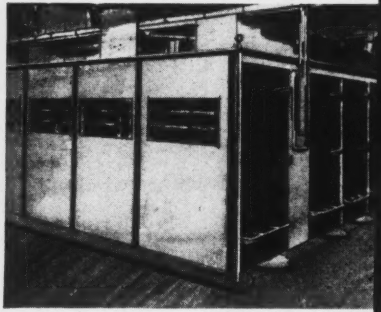
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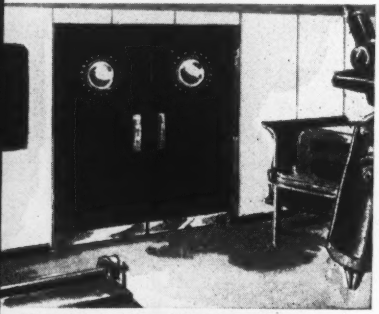
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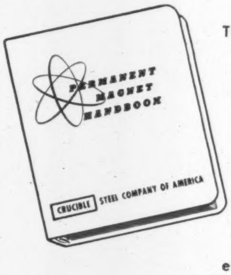
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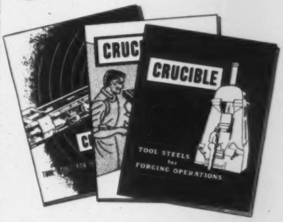
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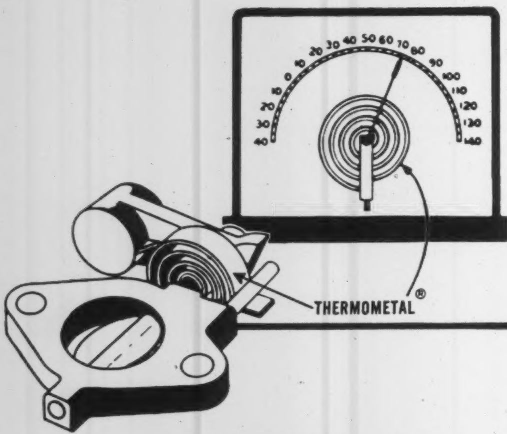

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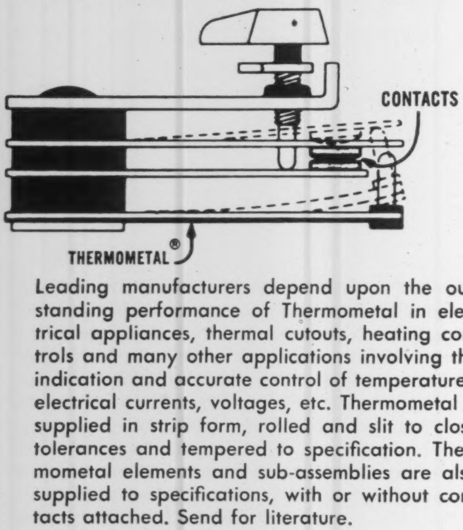

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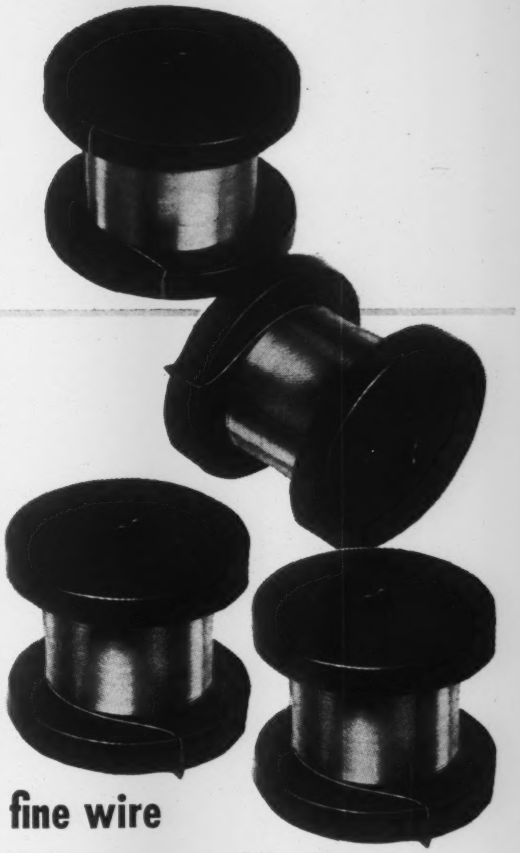

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SUPPLIERS' LITERATURE

Irons and Steels

Flat Rolled Steel. Alan Wood Steel Co., 8 pp, illus., No. D-39. Describes low alloy high strength flat rolled steel available in strip, coils, cut lengths and sheared plate in varying thicknesses. **1**

Special Steels. Allegheny Ludlum Steel Corp., 16 pp, illus. Physical, mechanical and electrical properties, corrosion resistance and uses of special stainless, tool and electrical steels, and carbide materials. **2**

Stainless Steel. Allegheny Ludlum Steel Corp., 40 pp, illus. Use of stainless steel in the chemical industry. Data on corrosion resistance of stainless steel to various media are included. **3**

Manganese Steel Products. American Manganese Steel Div., American Brake Shoe Co., 16 pp, illus., No. 2. Information on the use of manganese steel for hard facing and for construction equipment. **4**

Shaped Steel Wire. Page Steel & Wire Div., American Chain & Cable Co., Inc., 16 pp, illus. Sizes, tempers and finishes of square, rectangular, round, oval, hexagonal and octagonal wire made of low and high carbon steels, iron and stainless steels. **5**

Aluminized Steel. Armco Steel Corp., 22 pp, illus. Corrosion resistance, mechanical properties, fire resistance and heat reflectivity of aluminized steel. **6**

Alloy Steels. Bethlehem Steel Co., 36 pp, illus., No. 415-A. Individual effects of nickel, molybdenum, manganese, silicon, boron and aluminum as alloying elements for steel. **7**

Corrosion of Wrought Iron. A. M. Byers Co., 8 pp, illus., No. 15-D. Compares corrosion resistance of 4-D wrought iron with standard wrought iron and a ferrous substitute in such applications as hot water lines, heat exchangers, smoke stacks, tanks and brine lines. **9**

Stainless Steel Parts. G. O. Carlson Inc., 2 pp, illus. Shows typical stainless steel items produced to customer specifications. **10**

Chromized Steel. Chromalloy Corp., 4 pp, illus., No. 25. Heat resistance, uses, workability and cost of a chromized sheet steel material. **11**

Investment Casting Alloys. Consolidated Foundries & Mfg. Corp., Wai-Met Alloys Co. Div., 4 pp, illus. Information on tool and stainless steel certified alloys for investment castings. **12**

Leaded Steels. Copperweld Steel Co., Aristoloy Steel Div., 16 pp, illus. Mechanical properties and workability of leaded steels. **13**

Boron Stainless Steel. Superior Steel Div., Copperweld Steel Co., 8 pp, illus., No. 57. Chemical composition, microstructure, corrosion resistance, machinability and mechanical properties of a boron stainless steel for nuclear reactors. **14**

Carbon and Alloy Steels. Crucible Steel Co. of America, 74 pp. Chemical composition, heat treatment, properties and uses of high speed, tool, stainless, heat resisting, carbon, superalloy and special purpose steels and alloys. Information also on titanium. **15**

Fabricating Stainless Steel. Crucible Steel Co. of America, 162 pp, illus. Discusses forming, machining, cutting, joining, heat treating, pickling and finishing of austenitic, ferritic and martensitic stainless steels. **16**

Stainless Steel. Eastern Stainless Steel Corp., 4 pp, illus. Describes Type 321 SW grade of sheet and plate resulting from new method of melting ingots. **17**

Heat Treated Stainless Steels. Electric Steel Foundry Co., 12 pp, illus., No. 5. Mechanical properties of cast and wrought stainless steels after heat treatments at temperatures from 800 to 1200 F. **18**

High Purity Alloys. Firth Sterling Inc., 8 pp, illus. Room and elevated temperature properties, grain structure, chemical composition, forgeability and uses of high purity steel alloys melted by the Hopkins process. **19**

Corrosion Resistance of Stainless. Peter A. Frasse & Co., Inc., 2 pp. Information on the relative corrosion resistance of 34 standard grades of stainless steel. **20**

Ductile Iron. Hamilton Foundry, Inc., 6 pp, illus. Tensile strength, machinability, heat resistance, pressure tightness, impact resistance and rigidity of ductile (nodular) iron. **22**

Sponge Iron. Hoeganaes Sponge Iron Corp., 20 pp, illus. Tells what sponge iron is, traces its origin, and outlines its properties, characteristics, and use in quality steel. **23**

Ultra High Strength Steel. International Nickel Co., Inc., 14 pp. Properties and uses of an ultra high strength steel called 300-M. **25**

Stainless Steels. Jessop Steel Co., 16 pp. Corrosion resistance, physical and mechanical properties, and chemical composition for a series of stainless and heat resisting steels. **26**

Stainless Steel Sheet, Strip. Jones & Laughlin Steel Corp., Stainless & Strip Div., 4 pp, illus. Shows facilities for producing stainless steel sheet and strip to extremely close tolerances. **27**

Free-Machining Steel Bars. La Salle Steel Co. Strength, tolerances and machinability of a high strength, free-machining steel bar called Stressproof. **28**

Air Hardening Steel. Latrobe Steel Co., 8 pp, illus. Physical and mechanical properties, heat treatment, composition and high temperature properties of an air hardening steel. **29**

Clad Steels. Lukens Steel Co., 32 pp, illus. Mechanical and chemical properties, sizes, uses, design information and fabrication data for a series of nickel, stainless steel, Inconel and monel-clad steels. **30**

Metal Powders. Metals Disintegrating Co., Inc., Harrison Abrasive Div., illus. Description, specifications, properties and uses for all types of metal powders. **31**

Flat Spring Steel. Athenia Steel Div., National-Standard Co., Clifton, N. J., 28 pp, No. 579. Information on cold rolled high carbon flat spring steel. Included are tables giving weight calculations, decimal equivalents and Rockwell conversions. Write on company letterhead directly to Athenia Steel Div.

Zinc-Coated Steel. Weirton Steel Co., Div. of National Steel Corp., 12 pp, illus. Installation data, specifications, uses and characteristics of zinc-coated steel. **32**

Iron Powder. National-U. S. Radiator Corp., Plastic Metals Div., 4 pp. Properties of Plast-Iron Grade B-261 reduced iron powder used in making sintered compacts. **33**

Coated Steel Strip. Thomas Strip Div., Pittsburgh Steel Co., 20 pp, illus. Actual samples of strip steel electrolytically coated with zinc, copper, brass, lead alloy, nickel and chromium, in natural and buffed finishes. **34**

Tool Steel. H. K. Porter Co., Vulcan-Kidd Steel Div., 4 pp. Carbon, alloy and high speed tool steel chart listing 43 brand names now being produced by the company. **35**

Iron Powders. Pyron Corp., 8 pp, illus. Chemical and physical properties, and composition of hydrogen-reduced iron powders. **36**

Stainless Steel. Republic Steel Corp., illus. Information on cold forming, machining, forging, annealing, pickling, grinding and painting stainless steel. Charts give chemical composition and properties of the 300 and 400 series. **37**

Iron Powders. Republic Steel Corp., Metal Powder Div., 52 pp, illus., No. ADV 1014. Physical properties, uses, chemical composition and availability of four iron powders. **38**

Hot Rolled Steels. Joseph T. Ryerson & Son, Inc., 4 pp, illus., No. 11-2. Specifications and size ranges for hot rolled steel bars, structurals, plates, sheets and strip. **39**

Spring Steels. Sandvik Steel, Inc., 6 pp, illus. Sizes, materials and chemical composition of spring and specialty strip steels. **40**

Stainless Steel Strip. Seymour Mfg. Co., 6 pp, illus. Dimensions, properties, specifications and uses of stainless steel strip. **41**

Zinc-Coated Steel. Sharon Steel Corp., 12 pp, illus. Discusses welding, soldering, cold forming, cleaning and storage of Galvanite zinc-coated steel. **42**

Bar, Tube Stock. Centrifugally Cast Products Div., Shenango Furnace Co., No. 156. Properties and uses of standard bar and tube stock made of GC Meehanite Metal, GA Meehanite Metal and Type No. 1 Ni-Resist Alloys. **43**

Spring Steel. Uddeholm Co. of America, Inc., 43 pp, illus. Standard stock sizes for a wide variety of cold rolled spring steels. **44**

Columbium in Steel. Union Carbide Metals Co., Div. of Union Carbide Corp., 4 pp. Discusses the use of ferrocolumbium in carbon and low alloy steels, high temperature alloys, stainless steel and plain chromium steels. **45**

Constructional Alloy Steel. U. S. Steel Corp., illus. Properties and fabrication data for high strength, weldable steel. **46**

Designing with High Strength Steels. United States Steel Corp., 164 pp, illus. Discusses the essential principles of structural design and gives formulas, charts and tables to assist engineers in designing for high strength steels. **47**

Steel Strip. American Steel & Wire Co., Div. of U. S. Steel Corp., 48 pp, illus. Physical properties, dimensions, tempers and finishes of cold rolled stainless and carbon steel strip. **48**

Tool and Die Steel. Universal Cyclops Steel Corp., 12 pp, illus., No. TS-101. Properties, heat treatment, machinability, sizes and uses of a low temperature, air hardening tool and die steel. **49**

Alloy Metal Powders. Vanadium-Alloys Steel Co., Powder Metallurgy Dept., 8 pp, illus. Information on chromium-nickel and chromium stainless steel, nickel and silicon-iron, nickel-copper and nickel-chromium iron prealloyed powders used in metal powder parts production. **50**

Stainless Steel. Washington Steel Corp., 32 pp, illus. Physical properties, composition, fabrication, corrosion and heat resistance, and cleanability of special purpose stainless steel sheet and strip. **51**

Metals for Aircraft. Westinghouse Electric Corp., Blairsville Metals Plant, Materials Mfg. Dept., 8 pp, illus. Research in wrought alloys and molded metal products for high speed aircraft and missiles. **52**

High Strength, Low Alloy Steel. Youngstown Sheet & Tube Co., 4 pp, illus. Physical properties, corrosion resistance and chemical composition of a high strength low alloy steel called Yoloy E. **53**

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PROPERTIES OF MATERIALS

Irons and Steels

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Irons & Steels

Gray Irons—Cast

Class[a] →	20	25	30
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.26	0.26	0.26
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	24-34	24-34	24-34
Coef of Ther Exp (32-212 F), per °F	6 x 10^{-6}	6 x 10^{-6}	6 x 10^{-6}
Magnetic?	Yes	Yes	Yes
Electrical Resistivity (68 F), microhm-cm	Varies from 50 to 200 depending on composition		
MECHANICAL PROPERTIES[b]			
Mod of Elast in Tension, psi[c]	13, 12, 9 x 10^6	14, 13, 11.5 x 10^6	16, 15, 13.5 x 10^6
Tensile Strength (as cast), 1000 psi	24-29, 20-24, 15-19	27-33, 25-30, 20-24	35-40, 30-34, 20-24
Transverse Strength (as cast), 1000 lb[d]	1, 2, 5.2	1.25, 2.1, 5.5	1.4, 2.2, 7.3
Deflection (as cast), in.[d]	0.14, 0.25, 0.25	0.17, 0.27, 0.30	0.16, 0.28, 0.31
Modulus of Rupture (as cast), 1000 psi	50, 53, 40	57, 56, 42	63, 58, 56
Hardness (Brinell, as cast)[e]	200, 180, 170	205, 190, 175	210, 200, 180
Fatigue Strength (endurance limit, as cast), 1000 psi[f]	—, 10, —	—, 12.5, —	—, 14.5, —
Compressive Strength (as cast), 1000 psi[g]	100, 95, 90	—, 100, —	—, 115, —
Shear Strength (as cast), 1000 psi	—, 32, —	—, 37, —	—, 44, —
FABRICATING PROPERTIES	Gray cast iron, having a ferrite matrix in which graphite flakes are dispersed, has a machinability rating of 110. When a cast iron microstructure shows alloy segregation, free carbides, steadite and free pearlite, machinability is reduced and may be as low as 40. Some castings show several structures due to cooling rate and section size		
JOINING	Can be joined by gas welding; shielded metal-arc welding using special electrodes; carbon arc welding. Preheating necessary. Can be brazed with nonferrous filler metal		
CORROSION RESISTANCE	More resistant to some types of corrosion than carbon and low alloy steels, possibly because of graphite; cast iron soil pipe usually lasts longer than steel pipe, for example. Gray irons are resistant to strong sulfuric acid, cold concentrated phosphoric and nitric acids; attacked by dilute sulfuric, phosphoric and nitric acids. Resistant to many alkalis, including sodium hydroxide, soda ash and ammonia		
USES	Machine bases, grates, housings, ornamental castings, sanitary wear, piston rings, pipe and fittings	Similar to class 20 where higher strength is required	Light brake drums, clutch plates, cylinder blocks, liners, impellers, pipe and fittings, grate bars, machine parts

[a] Specified min tensile strength, 1000 psi, ASTM A48-48.

[b] Three values are given for light, medium and heavy sections, respectively.

[c] At ¼ max transverse load.

[d] Bar diameters 0.875, 1.2 and 2.0 in., respectively. Distance between supports 12, 18 and 24 in., respectively.

[e] Considerably wider range obtainable by heat treatment.

[f] About 40% of tensile strength appears to be safe level for endurance limit.

[g] In general, compressive strength is three to five times tensile strength.

Gray Irons—Cast

Class[a] →	35	40	50	60
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.26	0.26	0.26	0.26
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	24-34	24-34	24-34	24-34
Coef of Ther Exp (32-212 F), per °F	6 x 10^{-6}	6 x 10^{-6}	6 x 10^{-6}	6 x 10^{-6}
Magnetic?	Yes	Yes	Yes	Yes
Elec Res (68 F), microhm-cm	Varies from 50 to 200 depending on composition			
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi[c]	17, 16, 14.5 x 10^6	18, 17, 15.5 x 10^6	19, 19, 18 x 10^6	20, 19.5, 19 x 10^6
Ten Str (as cast), 1000 psi	38-42, 35-40, 25-33	50, 40-48, 33-45	60, 50-57, 52	70, 60-66, 50-75
Transverse Str (as cast), 1000 lb[d]	1.5, 2.6, 8	1.75, 2.9, 10	2, 3.3, 10.7	2.5, 3.7, 15
Deflection (as cast), in.[d]	0.17, 0.28 –	0.16, 0.28, 0.30	0.18, 0.28, 0.30	0.13, 0.34, 0.40
Mod of Rupture (as cast), 1000 psi	70, 69, 63	80, 78, 76	91, 88, 82	114, 98, 115
Hardness (Brinell, as cast)[e]	220, 210, 190	230, 220, 210	260, 240, 230	300, 290, 275
Fatigue Str (endur limit, as cast), 1000 psi[f]	–, 17.5, –	–, 21, –	–, 25, –	–, –, –
Compr Str (as cast), 1000 psi[g]	150, 125, –	–, 143, –	–, 150, –	–, 170, –
Shear Str (as cast), 1000 psi	–, 43, –	–, 57, –	–, –, –	–, –, –
FABRICATING PROPERTIES	Gray cast iron, having a ferrite matrix in which graphite flakes are dispersed, has a machinability rating of 110. When a cast iron microstructure shows alloy segregation, free carbides, steadite and free pearlite, machinability is reduced and may be as low as 40. Some castings show several structures due to cooling rate and section size			
JOINING	Can be joined by gas welding, shielded metal-arc welding using special electrodes, carbon arc welding. Preheating necessary. Can be brazed with nonferrous filler metal			
CORROSION RESISTANCE	More resistant to some types of corrosion than carbon and low alloy steels, possibly because of graphite; cast iron soil pipe usually lasts longer than steel pipe, for example. Gray irons are resistant to strong sulfuric acid, cold concentrated phosphoric and nitric acids; attacked by dilute sulfuric, phosphoric and nitric acids. Resistant to many alkalis, including sodium hydroxide, soda ash and ammonia			
USES	Clutch plates, crankcases, light brakedrums, liners, sleeves, cylinder blocks, impellers, machine components	Gears, camshafts, heads, liners, valves, pumps, tube supports, dies, wheels	Gears, valves, heads, blocks, steam pressure castings, dies, compressors, pumps, rams	Special brake drums, pressure castings, crusher frames, hot forming dies, heavy duty gears, hydraulic cylinders

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[a] Specified min tensile strength, 1000 psi, ASTM A48-48.

[b] **Three values are given for light, medium and heavy sections, respectively.**

[c] At ¼ max transverse load.

[d] **Bar diameters 0.875, 1.2 and 2.0 in., respectively. Distance between supports 12, 18 and 24 in., respectively.**

[e] **Considerably wider range obtainable by heat treatment.**

[f] **About 40% of tensile strength appears to be safe level for endurance limit.**

[g] **In general, compressive strength is three to five times tensile strength.**

Nodular or Ductile Irons—Cast

Type ➡	80-60-3	60-45-10	100-75-04[a]
COMPOSITION, %	T.C. 3.3–3.8, Si 2.0–3.0, Mn 0.2–0.5, P 0.06–0.08, Ni 0–1.0, Mg 0.02–0.07	T.C. 3.4–4.0, Si 2.0–2.75, Mn 0.2–0.6, P 0.06–0.08, Ni 0–1.0, Mg 0.02–0.07	T.C. 3.4–3.8, Si 2.0–2.75, Mn 0.3–0.6, P 0.08 max, Ni 0–2.5, Mo 0-1.0, Mg 0.02-0.07
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.257	0.257	0.257
Melting Temp Range, F	2050–2150	2050–2150	2050–2150
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	18	20	—
Coef of Ther Exp (70–400 F), per °F	6.6×10^{-6}	6.6×10^{-6}	6.6×10^{-6}
Electrical Resistivity (75 F), microhm-cm	68[b]	66[b]	—
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$22–25 \times 10^6$	$22–25 \times 10^6$	$22–25 \times 10^6$
Tensile Strength, 1000 psi	90–110	60–80	100–120
Yield Strength, 1000 psi	60–75	45–60	75–90
Elongation (in 2 in.), %	3–10	10–25	6–10
Hardness (Brinell)	200–270	140–190	200–240
Impact Strength (Charpy), ft-lb			
Unnotched	15–65	60–115	35–50
Notched	2–5	10–15	—
Fatigue Strength	Endurance ratio follows pattern of other ferrous materials. For soft ferritic materials, notched endurance ratio is about 50-55%; with stronger irons, the ratio drops to 30-40% or lower		
Compressive Strength	Ratio of compressive strength to tensile strength is about 2 to 1		
Creep Strength (0.0001%/hr), psi			
800 F	19,000	14,000	—
1000 F	1,750	4,000	—
1200 F	480	550	—
1400 F	—	—	—
THERMAL TREATMENT			
Ferritic Structure (ferritizing anneal)	Heat in 1600–1650 F range, cool to 1300 F, hold 1-3 hr, furnace cool to 1100 F, air cool		
Pearlitic-Ferritic Structures	Heat to 1600–1650 F, cool rapidly, reheat at 1100–1300 F		
Pearlitic Structures	Normalize by air cooling from 1600–1650 F		
Tempered Structures	Quench from 1400–1650 F (depending on composition), temper at 800–1300 F		
FABRICATING PROPERTIES			
Machinability	Depends on structure but has excellent machinability in both as-cast and annealed conditions		
Weldability	Can be welded by most fusion welding processes. For maximum ductility, welding should be done on fully annealed material. Composition affects weld quality. A 60 Ni-40% Fe filler wire is best for metal arc welding. Can be brazed with the lower melting BAg filler metals		
CORROSION RESISTANCE	Approx same corrosion resistance as gray irons of similar composition		
USES	Anvils for forging hammers; impellers, levers, cams, crankshafts, dies, jet engine burner support rings	Valve and pump bodies, pipe fittings, clamps, gear housings, tractor and farm machine parts	Track shoes, brake drums, gears, camshafts, pistons

[a] Obtained by heat treatment involving normalizing or quenching and tempering.
[b] Iron containing 1% silicon.

Nodular or Ductile Irons—Cast

Type ➔	120-90-02[a]	Heat Resistant	Austenitic
COMPOSITION, %	T.C. 3.4–3.8, Si 2.0-2.75, Mn 0.3–0.6, P 0.08 max, Ni 0–2.5, Mo 0–1.0, Mg 0.02–0.07	T.C. 2.8–3.8, Si 2.5–6.0, Mn 0.2–0.6, P 0.08 max, Ni 0–1.5, Mg 0.02–0.07	T.C. 3.0, Si 2.0-3.2, Mn 0.8–1.5, P 0.02 max, Ni 18–22, Cr 0–2.5
PHYSICAL PROPERTIES			
Density, lb/cu in	0.257	0.25	0.268
Melting Temp Range, F	2050–2150	2050–2150	2250
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	—	—	—
Coef of Ther Exp (70–400 F), per °F	6.6×10^{-6}	—	10.4×10^{-6}
Electrical Resistivity (75 F), microhm-cm	—	—	102
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$22\text{–}25 \times 10^6$	$22\text{–}25 \times 10^6$	18.5×10^6
Tensile Strength, 1000 psi	120–150	60–100	58–68
Yield Strength, 1000 psi	90–125	45–75	32–38
Elongation (in 2 in.), %	2–7	0–20	7–40[c]
Hardness (Brinell)	240–325	140–300	140–200
Impact Strength (Charpy), ft-lb			
Unnotched	25–40	5–115	—
Notched	—	—	10–28
Fatigue Strength	Endurance ratio follows pattern set with other ferrous materials. For soft ferritic materials, notched endurance ratio is 50–55%; with the stronger irons, ratio drops to 30–40% or lower		
Compressive Strength	Ratio of compressive strength to tensile strength is about 2 to 1		
Creep Strength (0.0001%/hr), psi[d]			
800 F	—	—	18,500
1000 F	—	—	13,000
1200 F	—	—	5,700
1400 F	—	—	2,000
THERMAL TREATMENT			
Ferritic Structure (ferritizing anneal)	Heat in 1600–1650 F range, cool to 1300 F, hold 1–3 hr, furnace cool to 1100 F, air cool		—
Pearlitic-Ferritic Structures	Heat to 1600–1650 F, cool rapidly, reheat at 1100–1300 F		—
Pearlitic Structures	Normalize by air cooling from 1600–1650 F		—
Tempered Structures	Quench from 1400–1650 F (depending on composition), temper at 800–1300 F		—
FABRICATING PROPERTIES			
Machinability	Depends on structure but is excellent in both as-cast and annealed conditions		
Weldability	Can be welded by most fusion welding processes. For maximum ductility, welding should be done on fully annealed material. Composition affects weld quality. A 60 Ni-40% Fe filler wire is best for metal arc welding. Can be brazed with the lower melting BAg filler metals		
CORROSION RESISTANCE	Approx same corrosion resistance as gray irons of similar composition; superior to ordinary gray irons		
USES	Machine guides, pinions, gears, cams, dies, track rollers	Grate boxes, sinter pots, lead pots, glass molds, furnace doors	Impellers, grids, paper mill machine parts, pumps, valves

[a] Obtained by heat treatment involving normalizing or quenching and tempering.
[c] 25–40% with 0% chromium.
[d] For 0% chromium.

Malleable Irons—Cast

Type and Grade ➡	Standard		Pearlitic
	32510	35018	
COMPOSITION, %	C 2.3–2.7, Si 1.5–0.8, Mn 0.55 max, P 0.18 max, S 0.20 max	C 2.0–2.45, Si 1.4–0.85, Mn 0.55 max, P 0.18 max, S 0.20 max	Same as standard grades except that manganese can be higher
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.259–0.263	0.259–0.263	0.259–0.263
Thermal Conductivity, Btu/hr/sq ft/°F/ft			
80 F	29.5	29.5	[a]
700 F	23.0	23.0	[a]
Coef of Ther Exp (68–750 F), per °F	6.6×10^{-6}	6.6×10^{-6}	[a]
Specific Heat (70-750 F), Btu/lb/°F	0.133	0.133	—
Electrical Resistivity (68 F), microhm-cm	32.0	32.0	38.19–41.17
Magnetic?	Yes	Yes	Yes
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	25×10^6	25×10^6	28×10^6
Tensile Strength, 1000 psi	50–52	53–60	60–90
Yield Strength, 1000 psi	32–35	35–40	40–70
Elongation (in 2 in.), %	10–18	18–25	12–3
Reduction of Area, %	18–23	18–23	—
Hardness (Brinell)	110–145	110–145	160–285
Impact Strength (Charpy), ft-lb[c]	16.5	16.5	12
Fatigue Strength			
Endurance Limit, 1000 psi	25	31	30–32
Endurance Ratio	0.50	0.50	—
Mod of Elast in Compression, psi	25×10^5	25×10^5	—
Compressive Yield Strength, 1000 psi			
1% Permanent Set	28	28	43
At Failure	90+	90+	—
Ultimate Shear Strength, 1000 psi	45–48	48–54	—
Yield Strength in Shear, 1000 psi	29–32	32–36	—
Mod of Rupture in Torsion, psi	58,000	58,000	—
Poisson's Ratio	0.17	0.17	—
Allowable Working Stress (775 F), psi	5600	5600	—
THERMAL TREATMENT			
Hardening Temp, F	1500[b]	1500[b]	1500
Tempering Temp, F	—	—	About 600
FABRICATING PROPERTIES			
Casting Temperature Range, F	2600–2800	2600–2850	2600–2850
Shrinkage Allowance (contraction minus expansion during anneal), in.	11/64–1/32	11/64–1/32	11/64–1/32
Machinability Index (AISI B1112 steel = 100)	120	120	80–90
Weldability	Not fusion welded. Can be soldered and brazed		
CORROSION RESISTANCE	Resistant to atmospheric corrosion in rural, industrial and marine atmospheres; fresh and salt waters		
USES	Gear cases, brake supports, journal boxes, pipe fittings, pole line hardware, ordnance parts, marine deck fittings, anchors, parts for domestic appliances and business machines		Rocker arms, camshafts, gears, sprockets, tractor parts, agricultural machinery parts

[a] Estimated to be somewhat higher than for standard grades.
[b] Must be first heated to 1700 F to dissolve graphitic carbon.
[c] V-notch 0.079 in. deep, 0.394-in. sq bar.

Ingot and Wrought Irons

Type ➡	Ingot Iron	Wrought Iron	
COMPOSITION, %	C<0.02, Mn<0.02, Si trace, P 0.005, S 0.02	C 0.02, Mn 0.05, Si 0.15, P 0.12, S 0.02, slag 2.5	
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.28	0.278	
Melting Point, F	2794	2750	
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	38	34.5	
Coef of Ther Exp (68–212 F), per °F	6.8×10^{-6}	7.4×10^{-6}	
Specific Heat, Btu/lb/°F	0.11	0.11	
Electrical Resistivity (68 F), microhm-cm	9.7	—	
Magnetic?	Yes	Yes	
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	29.8×10^6	29.5×10^6	
		Longitudinal[a]	Transverse[a]
Tensile Strength, 1000 psi			
Annealed	42	—	—
Hot Rolled	44	48	34
Cold Drawn	73	—	—
Yield Point, 1000 psi			
Annealed	19	—	—
Hot Rolled	23	27	23
Cold Drawn	69	—	—
Elongation (in 2 in.), %			
Annealed	48	—	—
Hot Rolled	47	14	7
Cold Drawn	12	—	—
Reduction of Area, %			
Annealed	76	—	—
Hot Rolled	75	48	12
Cold Drawn	63	—	—
Hardness (Brinell)			
Annealed	69	—	—
Hot Rolled	83	97–105	105
Cold Drawn	142	—	—
Impact Strength (Charpy), ft-lb			
Annealed	19	—	—
Hot Rolled	—	24–28	11
Cold Drawn	—	—	—
Fatigue Strength (endurance limit), 1000 psi			
Annealed	26	—	—
Hot Rolled	28	23	19
Cold Drawn	33	—	—
FABRICATING PROPERTIES			
Annealing Temperature, F	1700–1800	1300–1400	
Forging Temperature Range, F	—	2100–2200	
Bending Temperature Range, F	—	1300–1400	
Machinability Index (AISI B1112 Steel = 100)	50	50	
Weldability	Readily joined by resistance, arc and gas methods		
CORROSION RESISTANCE	In spite of its purity, ingot iron has corrosion rates much the same as plain carbon steel	Current improved wrought iron has at least 25% greater corrosion resistance than former grade. Shows its greatest advantage over carbon steels in heat transfer equipment handling brines, industrial cooling waters and industrial flue gases	
AVAILABLE FORMS	Sheet and strip, wire, rail sections	Tubular products, plate, sheet, bars, structural shapes, wire, chain	
USES	Deep drawn parts, enameling stock, third rails, wire for electrical apparatus	Oil well casing, heat exchangers, piping for fresh and salt water, tanks, bolts and nuts, roofing, chemical processing equipment, chains	

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[a] As rolled.

Low Carbon Steels—Wrought

AISI Type ➜	C1010	C1015	C1018	C1020	C1025
COMPOSITION, %	C 0.08–0.13, Mn 0.30–0.50, P 0.040 max, S 0.050 max	C 0.13–0.18, Mn 0.30–0.60, P 0.040 max, S 0.050 max	C 0.15–0.20, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.18–0.23, Mn 0.30–0.60, P 0.040 max, S 0.050 max	C 0.22–0.28, Mn 0.30–0.60, P 0.040 max, S 0.050 max
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Melting Temp Range, F	2750–2775	2750–2775	2750–2775	2750–2775	2750–2775
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.4×10^{-6}	8.4×10^{-6}	8.4×10^{-6}	8.4×10^{-6}	8.4×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	14.3	14.3	14.3	14.3	14.3
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$
Ten Str, 1000 psi					
Hot Rolled	51	61	69	65	70
Cold Worked	56	74	82	78	80
Yld Str, 1000 psi					
Hot Rolled	29	46	48	43	45
Cold Worked	33	62	70	66	69
Elong (in 2 in.), %					
Hot Rolled	38	39	38	36	31
Cold Worked	35	24	20	20	18
Red. of Area, %					
Hot Rolled	70	61	62	59	58
Cold Worked	65	57	57	55	48
Hardness (Brinell)					
Hot Rolled	101	126	143	143	143
Cold Worked	113	143	163	156	162
Impact Str	Markedly dependent on section size and processing details, such as deoxidation practice, rolling practice, etc.—more so than other mechanical properties				
Fatigue Str	Dependent on thermal and mechanical history, though not to the extent that impact strengths are. Conservative estimate of fatigue strength is 40–50% of tensile strength				
THERMAL TREATMENT					
Annealing Temp, F	1650–1750	1650–1750	1650–1750	1650–1750	1600–1700
Hardening Temp, F	1650–1700[a]	1650–1700[a]	1650–1700[a]	1600–1675[b]	1600–1675[b]
Tempering Temp, F	300–1350	300–1350	300–1350	300–1350	300–1350
FABRICATING PROPERTIES					
Machinability Index[c]					
Hot Rolled	40	50	52	50	52
Cold Worked	45	58	65	60	65
Weldability	Easily welded by all commercial welding procedures, including gas, arc, bronze, thermit, oxyacetylene and submerged-melt processes. Resulting welds are of extremely high quality				
CORROSION RESISTANCE	Rusted by oxygen and water at room temperature, rate of attack increasing sharply as pH goes above 4 and decreasing below a pH of 8. Dilute salt solutions increase corrosion rate. Attacked by acids, in general, but satisfactorily resistant to alkalis at normal temperatures. Corrosion rate in ordinary rusting not appreciably affected by carbon or alloy content or by cold working				
AVAILABLE FORMS	Can be obtained in all mill forms. "Structural mild steel," in which the common shapes are supplied unless otherwise specified, falls somewhere in these ranges of composition				
USES	Can be carburized to give a hard surface on a part which retains its tough inner core. Machine applications apart from structural shapes include automobile spiders, gears, clutch disks, bolts, bearing races, camshafts, crankshafts, piston pins, cams, pneumatic tool cylinders, gun blocks, bushings, stud and collar bolts, shifter shoes, draw bars, pivot pins, cap screws, precision shafting, scythe blade heels, flanges, shackles, tie rods, drag links, steering gear connecting rods, thrust washers, wrenches				

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[a] Quench in water, brine or caustic frequently used.
[b] Soluble oil solution used for hardening bolts; mineral oil used when quenching for machinability.
[c] Based on AISI B1112 steel = 100.

Medium Carbon Steels—Wrought

AISI Type ➜	**C1030**	**C1035**	**C1040**	**C1045**
COMPOSITION, %	C 0.28–0.34, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.32–0.38, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.37–0.44, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.43–0.50, Mn 0.60–0.90, P 0.040 max, S 0.050 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Melting Temp Range, F	2700–2750	2700–2750	2700–2750	2700–2750
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}
Specific Heat, Btu/lb °F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	19	19	19	19
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$
Ten Str, 1000 psi				
Hot Rolled	80	85	91	98
Cold Worked	85	92	100	103
Hard. & Temp	98[a]	103[b]	113[b]	120[c]
Yld Str, 1000 psi				
Hot Rolled	50	54	58	59
Cold Worked	72	79	88	90
Hard. & Temp	70[a]	72[a]	86[b]	90[b]
Elong (in 2 in.), %				
Hot Rolled	30	30	27	24
Cold Worked	26	25	17	14
Hard. & Temp	27[a]	23[b]	23[b]	18[b]
Red. of Area, %				
Hot Rolled	56	53	50	45
Cold Worked	51	50	42	40
Hard. & Temp	64[a]	59[b]	62[b]	52[c]
Hardness (Brinell)				
Hot Rolled	163	183	201	212
Cold Worked	179	201	207	217
Hard. & Temp	212[a]	230[b]	235[b]	277[c]
Impact Str	Markedly dependent on section size and processing details such as deoxidation practice, rolling practice, etc.—more so than other mechanical properties			
Fatigue Str	Dependent on thermal and mechanical history, though not to the extent that impact strengths are. A conservative estimate of fatigue strength is 40–50% of tensile strength			
THERMAL TREATMENT				
Annealing Temp, F	1550–1700	1500–1650	1450–1600	1450–1600
Hardening Temp, F[d]	1575–1650	1525–1600	1500–1575	1475–1550
Tempering Temp, F	300–1350	300–1350	300–1350	300–1350
FABRICATING PROPERTIES				
Machinability Index (AISI B1112 steel=100)				
Cold Worked	67	67	65	60
Hard. & Temp	55	55	55	50
Weldability	Easily welded by all commercial procedures including gas, arc, bronze, thermit, oxyacetylene and submerged-melt. Preheat and postheat treatments frequently necessary			
CORROSION RESISTANCE	Rusted by oxygen and water at room temperature, rate of attack increasing sharply as the pH goes above 4 and decreasing below a pH of 8. Dilute salt solutions increase corrosion rate. Attacked by acids, in general, but satisfactorily resistant to alkalis at normal temperatures. Corrosion rate in ordinary rusting not appreciably affected by carbon or alloy content or by cold working			
AVAILABLE FORMS	Can be furnished in all standard mill forms			
USES	Shafts, brake shoe parts, gears, tie rods, brake and clutch pedals, truck rim side rings, sucker rods, connecting rods, shifter levers, pitman arms, flywheel rings, I-beam axles, crankshafts, camshafts, wheel hubs, pins, tools, plowshares, sway bars, mine bits, lock washers, bumper bars, springs, road scraper blades, scarifier teeth, grinding balls			

[a] 1-in. round water quenched 1575, tempered at 1000 F.

[c] 1-in. round water quenched 1550, tempered at 1000 F.

[b] 1-in. round water quenched 1525 F, drawn at 1000 F.

[d] Quenched in oil, water, or brine or caustic solutions.

High Carbon Steels—Wrought

AISI Type ➡	C1055	C1060	C1070	C1080	C1095
COMPOSITION, %	C 0.50–0.60, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.55–0.65, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.65–0.75, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.75–0.88, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.90–1.05, Mn 0.30–0.50, P 0.040 max, S 0.050 max
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27
Coef of Ther Exp (70-1200 F), per °F	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	18	18	18	18	18
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$
Ten Str, 1000 psi					
Annealed (1450 F)	97	105	112	119	100
Hot Rolled	109	116	128	141	142
Hard. & Temp	150[a]	160[a]	174[b]	189[b]	180[c]
Yld Str, 1000 psi					
Annealed	52	54	60	66	53
Hot Rolled	65	70	77	84	84
Hard. & Temp	105	112	127	142	118
Elong (in 2 in.), %					
Annealed	24	20	17	15	21
Hot Rolled	19	17	15	12	9
Hard. & Temp	14	12	13	14	11
Red. of Area, %					
Annealed	47	44	34	22	42
Hot Rolled	38	36	27	17	18
Hard. & Temp	45	40	37	34	30
Hardness (Brinell)					
Annealed	185	192	207	223	197
Hot Rolled	235	241	267	293	293
Hard & Temp	307	321	354	388	375
Impact Str (Izod), ft-lb					
Annealed	22	15	11	6	5
Hot Rolled	18	13	9	5	3
Hard. & Temp	22	15	13	10	5
THERMAL TREATMENT					
Normalizing Temp, F	1525-1650	1525-1650	1525-1650	1525-1650	1525-1650
Annealing Temp, F	1500-1575	1500-1575	1500-1575	1500-1575	1500-1575
Hardening Temp, F	1450-1550	1450-1550	1450-1525	1450-1500	1430-1500
Tempering Temp, F	400-1300	400-1300	400-1300	400-1300	400-1300
FABRICATING PROPERTIES					
Hot Working Temp Range, F	1550-1650	1550-1650	1550-1650	1550-1650	1550-1650
Machinability Index (annealed)[d]	55	53	45	44	43
Weldability	High carbon content introduces difficulties in welding. Can be welded satisfactorily by thermit process. Welding by gas and arc methods is difficult, and resulting welds are only moderately satisfactory				
CORROSION RESISTANCE	Rust when brought into contact with moisture and air at room temperature; rates not appreciably affected by carbon content. If salts are present, corrosion rate is increased. Attacked readily by acids, but resistant to alkalis at ordinary temperatures				
AVAILABLE FORMS	Cold rolled strip, hot rolled strip, flat bars, forgings				
USES	Heavy machine parts, such as shafts, braces and control rods; hand tools, including open-end and Stillson wrenches, hammers, pliers, screwdrivers, hatchets and axes; agricultural machinery parts, such as plowshares, mold boards, disks for harrows, and mower knives; and flat and helical springs				

[a] 1-in. round, normalized 1650 F, reheated to 1550 F, oil quenched, tempered 700 F.
[b] 1-in. round, normalized 1650 F, reheated to 1525 F, oil quenched, tempered 700 F.
[c] 1-in. round, normalized 1650 F, reheated to 1475 F, oil quenched, tempered 700 F.
[d] Based on AISI B1112 steel = 100.

Free-Cutting Steels—Wrought

AISI Type[a] ➡	B1111, C1211	B1112, C1212	B1113, C1213
COMPOSITION, %	C 0.13 max, Mn 0.60–0.90, P 0.07–0.12, S 0.08–0.15	C 0.13 max, Mn 0.70–1.00, P 0.07–0.12, S 0.16–0.23	C 0.13 max, Mn 0.70–1.00, P 0.07–0.12, S 0.24–0.33
PHYSICAL PROPERTIES			
Density, lb/cu in	0.283	0.283	0.283
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.4×10^{-6}	8.4×10^{-6}	8.4×10^{-6}
Specific Heat, Btu/lb/°F	0.10–0.11	0.10–0 11	0.10–0.11
Electrical Resistivity (68 F), microhm-cm	14.3	14.3	14.3
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	29×10^6	29×10^6	29×10^6
Tensile Strength, 1000 psi[c]			
9/16-In. Dia	85–110	85–110	85–110
1-In. Dia	80–105	80–105	80–105
2-In. Dia	70–90	70–90	70–90
Yield Strength, 1000 psi[c]			
9/16-In. Dia	75–100	75–100	75–100
1-In. Dia	70–90	70–90	70–90
2-In. Dia	60–85	60–85	60–85
Elongation (in 2 in.), %[c]			
9/16-In. Dia	10–20	10–20	10–20
1-In. Dia	12–22	12–22	12–22
2-In. Dia	10–20	10–20	10–20
Reduction of Area, %[c]			
9/16-In. Dia	30–50	30–50	30–50
1-In. Dia	35–55	35–55	35–55
2-In. Dia	30–50	30–50	30–50
Hardness (Brinell)[c]			
9/16-In. Dia	B90–102[b]	B90–102[b]	B90–102[b]
1-In. Dia	163–229	163–229	163–229
2-In. Dia	149–202	149–202	149–202
Impact Strength	Relatively low impact strength at low temperatures; should not be used for shock loading applications at subzero temperatures		
Fatigue Strength	Notch sensitive as cold drawn. Polished fatigue specimens will show expected values but poor finishing or processing of parts may cause low and erratic results for finished parts under dynamic or alternating stresses of relatively low intensity		
THERMAL TREATMENT			
Case Hardening	Case hardened for high surface hardness and good wear resistance where core properties not important Case hardness Rockwell C60–65		
Case Hardening Temp, F[d]	1450–1700	1450–1700	1450–1700
Tempering Temp, F	300	300	300
FABRICATING PROPERTIES			
Workability	Not recommended for operations involving cold metal movement, such as crimping, forming or bending		
Machinability Index[e]	90	100	125
Machining Speed (avg), sfm	153	170	213
AVAILABLE FORMS	Cold drawn shapes		
USES	Studs, nuts, fasteners, sleeves, collars, spacers, dowels, rods, handles, levers		

[a] B1111, B1112, B1113 are bessemer steels. C1211, C1212, C1213 are basic open hearth steels.
[b] **Rockwell hardness.**
[c] **Cold drawn.**
[d] **Quench in water or oil.**
[e] Based on AISI B1112 Steel = 100.

Low Alloy Steels (13xx)—Wrought

AISI Type ➡	1320	1321	1330	1335	1340
COMPOSITION, %	C 0.18–0.23, Mn 1.60–1.90, Si 0.20–0.35, P 0.040 max, S 0.040 max	C 0.17–0.22, Mn 1.80–2.10, Si 0.20–0.35, P 0.050 max, S 0.050 max	C 0.28–0.33, Mn 1.60–1.90, Si 0.20–0.35, P 0.040 max, S 0.040 max	C 0.33–0.38, Mn 1.60–1.90, Si 0.20–0.35, P 0.040 max, S 0.040 max	C 0.38–0.43, Mn 1.60–1.90, Si 0.20–0.35, P 0.040 max, S 0.040 max
PHYSICAL PROPERTIES					
Density, lb/cu in	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27
Coef of Ther Exp (68–1200 F), per °F	7.9 x 10^{-6}	7.9 x 10^{-6}	7.9 x 10^{-6}	7.9 x 10^{-6}	7.9 x 10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	17	17	17	17	17
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6
Ten Str, 1000 psi					
Annealed	84	90	97	104	110
Cold Drawn	102	107	113	119	—
Hard. & Temp	100[b]	—	122[c]	126[d]	137[d]
Yld Point, 1000 psi					
Annealed	72	80	83	90	94
Cold Drawn	80	87	93	100	—
Hard. & Temp	73.5	—	100	105	118
Elong (in 2 in.), %					
Annealed	24	22	21	19.5	18
Cold Drawn	20	18	15	14	—
Hard. & Temp	28	—	19	20.5	19
Red. of Area, %					
Annealed	60	58	57	55	54
Cold Drawn	57	55	50	47	—
Hard. & Temp	65	—	52	59	55
Hardness (Brinell)					
Annealed	179	187	197	212	223
Cold Drawn	207	212	235	248	—
Hard. & Temp	217	—	248	262	285
Impact Str (Izod), ft-lb					
Annealed	—	—	—	—	52
Cold Drawn	80	—	—	—	56
THERMAL TREATMENT					
Annealing Temp, F	1500–1600	1500–1600	1500–1600	1500–1600	1500–1600
Hardening Temp, F	1575–1625	1575–1625	1500–1575	1500–1550	1500–1550
FABRICATING PROPERTIES					
Machinability Index[e] (annealed or cold drawn)	65	63	62	62	59
Weldability	Manganese increases crack sensitivity of welded joints, particularly when this sensitivity is associated with higher carbon contents. Welding practice must be controlled accordingly				
CORROSION RESISTANCE	Rust at rates similar to those of carbon steels when brought into contact with moisture and air. If salts are present, corrosion rates are increased. Attacked readily by acids, but resistant to alkalis at ordinary temperatures				
AVAILABLE FORMS	Billets, hot rolled bars, cold finished bars, forgings				
USES	Automotive, farm implement and miscellaneous industrial applications, including axles, drive shafts, propeller shafts, bolts, studs, gears and tie rods				

[a] Mechanical properties determined on 1-in. round bars.
[b] Pseudo-carburized at 1700 F for 8 hr, oil quenched, tempered at 300 F, reheated at 1475 F.
[c] Water quenched from 1525 F, tempered at 1000 F.
[d] Oil quenched from 1525 F, tempered at 1000 F.
[e] Based on AISI B1112 steel = 100.

Low Alloy Steels (23xx, 25xx)—Wrought

AISI Type ➜	2317	2 30	2512	2515	2517
COMPOSITION, %	C 0.15–0.20, Mn 0.40–0.60, Si 0.20–0.35, Ni 3.25–3.75	C 0.28–0.33, Mn 0.60–0.80, Si 0.20–0.35, Ni 3.25–3.75	C 0.09–0.14, Mn 0.40–0.60, Si 0.20–0.35, Ni 4.75–5.25	C 0.12–0.17, Mn 0.40–0.60, Si 0.20–0.35, Ni 4.75–5.25	C 0.15–0.20, Mn 0.40–0.60, Si 0.20–0.35, Ni 4.75–5.25
PHYSICAL PROPERTIES					
Density, lb/cu in	0.283	0.283	0.283	0.283	0.283
Melting Point, F	2620	2600	2620	2615	2610
Ther Cond (120 F), Btu/hr/sq ft/°F/ft	38.3	38.3	34.5–38.5	34.5–38.5	34.5–38.5
Coef of Ther Exp, per °F					
0 to 200 F	6.2×10^{-6}	6.2×10^{-6}	6.0×10^{-6}	6.0×10^{-6}	6.0×10^{-6}
0 to 1200 F	8.0×10^{-6}	8.0×10^{-6}	7.8×10^{-6}	7.8×10^{-6}	7.8×10^{-6}
Spec Ht (68–212 F), Btu/lb/°F	0.11–0.12	0.11–0.12	0.11–0.12	0.11–0.12	0.11–0.12
Elec Res (annealed), microhm-cm					
120 F	28.4	28.4	27–29	27–29	27–29
570 F	46.8	46.8	—	—	—
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$
Ten Str, 1000 psi					
Hot Rolled	81	97	86	90	92
Annealed	77	90	77	80	82
Cold Drawn	95	110	—	103	—
Hard. & Temp (1000 F)[b]	107	125	105	113	120
Yld Str, 1000 psi					
Hot Rolled	55	67	62	67	70
Annealed	53	64	61	63	65
Cold Drawn	75	90	—	75	—
Hard. & Temp (1000 F)[b]	72	96	85	94	100
Elong (in 2 in.), %					
Hot Rolled	29	24	28	26	26
Annealed	31	27	30	25	29
Cold Drawn	25	17	—	24	—
Hard. & Temp (1000 F)[b]	27	22	28	25	22
Red. of Area, %					
Hot Rolled	62	51	70	67	65
Annealed	61	54	72	71	70
Cold Drawn	58	47	—	62	—
Hard. & Temp (1000 F)[b]	71	60	73	69	66
Hardness (Brinell)					
Hot Rolled	160	195	170	180	184
Annealed	152	180	157	160	162
Cold Drawn	197	235	—	207	—
Hard. & Temp (1000 F)[b]	222	270	217	233	244
Impact Str (Izod, hard. & temp at 1000 F)[b], ft-lb	84	55	95	85	80
THERMAL TREATMENT					
Annealing Temp, F	1550	1500	1525	1500	1500
Normalizing Temp, F	1550	1500	1525	1500	1500
Hardening Temp, F	1475	1450	1475	1475	1475
FABRICATING PROPERTIES					
Max Forging Temp, F	2300	2250	2300	2300	2300
Machinability Index[c]	55	50	—	40	—
Weldability	Good	Good	Good	Good	Good
CORROSION RESISTANCE	Better corrosion resistance than plain carbon steels				
AVAILABLE FORMS	Usually supplied as bar stock or forgings, but can be obtained in all steel mill forms		Usually supplied as bar stock, tubing or forgings, but can be obtained in all steel mill forms		
USES	Carburized parts; gears, cams	Shafting, heavy forgings, gears	Heavy duty carburized parts such as aircraft gears and piston pins. Uncarburized, used for corrosion resistant process equipment		

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[a] For design purposes, fatigue strength is approximately 50% of tensile strength. Compressive yield strength is about equal to tensile yield strength Shear strength is about 5 to 10% less than tensile strength.

[b] Properties after heat treatment are based on oil quench and 1-in. round bars.

[c] Based on AISI B1112 steel = 100.

Low Alloy Steels (40xx)—Wrought

AISI Type ➡	4023	4032	4042	4053	4063
COMPOSITION, %	C 0.20–0.25, Mn 0.70–0.90, P 0.040 max, S 0.040 max, Si 0.20–0.35, Mo 0.20–0.30	C 0.30–0.35, Mn 0.70–0.90, P 0.040 max, S 0.040 max, Si 0.20–0.35, Mo 0.20–0.30	C 0.40–0.45, Mn 0.70–0.90, P 0.040 max, S 0.040 max, Si 0.20–0.35, Mo 0.20–0.30	C 0.50–0.56, Mn 0.75–1.00, P 0.040 max, S 0.040 max, Si 0.20–0.35, Mo 0.20–0.30	C 0.60–0.67, Mn 0.75–1.00, P 0.040 max S 0.040 max, Si 0.20–0.35, Mo 0.20–0.30
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	19	19	19	19	19
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$	$29\text{–}30 \times 10^6$
Ten Str, 1000 psi					
Annealed, Cold Drawn	88	92	96	102	109
Cold Drawn	90	104	117	127	137
Hard. & Temp	120[a], 108[b]	210[c], 140[d]	235[e], 158[f]	250[g], 165[h]	269[i], 173[j]
Yld Point, 1000 psi					
Annealed, Cold Drawn	76	79	82	88	94
Cold Drawn	75	89	101	108	115
Hard. & Temp	85[a], 64[b]	182[c], 128[d]	210[e], 140[f]	223[g], 150[h]	231[i], 150[j]
Elong (in 2 in.), %					
Annealed, Cold Drawn	22	20	19	18	16
Cold Drawn	21	17	16	14	13
Hard. & Temp	20[a], 21[b]	11[c], 18[d]	10[e], 15[f]	12[g], 16[h]	8[i], 13[j]
Red. of Area, %					
Annealed, Cold Drawn	57	54	53	51	48
Cold Drawn	55	51	49	45	40
Hard. & Temp	53[a], 54[b]	49[c], 63[d]	42[e], 60[f]	40[g], 56[h]	15[i], 40[j]
Hardness (Brinell)					
Annealed, Cold Drawn	179	192	202	212	223
Cold Drawn	183	217	241	262	277
Hard. & Temp	255[a], 229[b]	415[c], 302[d]	461[e], 302[f]	495[g], 352[h]	534[i], 380[j]
Fatigue Str, 1000 psi	Endurance limit is proportional to tensile strength in same ratio as in other low alloy steels. Below 400 Bhn, ratio is about 50%; at higher hardness, endurance limit is about 45% of tensile strength				
THERMAL TREATMENT					
Annealing Temp, F	1650	1550–1600	1525–1575	1450–1550	1450–1550
Hardening Temp (oil quench), F	[k]	[l]	1500–1575	1475–1550	1475–1550
FABRICATING PROPERTIES					
Machinability Index (AISI B1112 = 100)	73	70	65	56	52
Weldability	Can be welded by procedures used for carbon steels. Molybdenum increases hardenability; preheating or postheating may be required				
CORROSION RESISTANCE	Similar to carbon steels				
USES	Automotive parts such as countershafts, transmission shafts, spline and differential gears	Automotive transmission gears and pinions, bolts	Leaf and coil springs, bolts, axles, steering arms and knuckles. Hand tools such as screw drivers		Leaf and coil springs. Hand tools such as chisels

[a] 1-in. round pseudo-carburized 8 hr at 1700 F, oil quenched, tempered 1 hr at 300 F.

[b] Same as [a] but reheated at 1475 F, oil quenched.

[c] Water quenched from 1525 F, tempered at 600 F.

[d] Water quenched from 1525 F, tempered at 1000 F.

[e] Oil quenched from 1500 F, tempered at 600 F.

[f] Oil quenched from 1500 F, tempered at 1000 F.

[g] Oil quenched from 1475 F, tempered at 600 F

[h] Oil quenched from 1475 F, tempered at 1000 F.

[i] Oil quenched from 1450 F, tempered at 600 F.

[j] Oil quenched from 1450 F, tempered at 1000 F.

[k] Carburize 1650-1700 F; quench fine grained steels directly from carburizing temperature.

[l] Carburize 1650-1700 F; quench fine grained steels directly from carburizing temperature. Water quench from 1500-1550 F if not carburized.

Low Alloy Steels (41xx)—Wrought

AISI Type➡	4118	4130	4140	4150
COMPOSITION, %	C 0.18-0.23, Mn 0.70-0.90, Si 0.20-0.35, Cr 0.40-0.60, Mo 0.08-0.15	C 0.28-0.33, Mn 0.40-0.60, Si 0.20-0.35, Cr 0.80-1.10, Mo 0.15-0.25	C 0.38-0.43, Mn 0.75-1.00, Si 0.20-0.35, Cr 0.80-1.10, Mo 0.15-0.25	C 0.48-0.53, Mn 0.75-1.00, Si 0.20-0.35, Cr 0.80-1.10, Mo 0.18-0.25
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.28	0.28	0.28	0.28
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	24.7	24.7	24.7	24.7
Spec Ht, Btu/lb/°F	0.11	0.11	0.11	0.11
Elec Res (68 F), microhm-cm	22.3	22.3	22.3	22.3
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29 x 10^6	29 x 10^6	29 x 10^6	30 x 10^6
Ten Str, 1000 psi				
Normalized	90	108	120-138	155
Hard. & Temp	—	200[b], 140[c]	200[d], 135[e]	230[f], 160[g]
Yld Str, 1000 psi				
Normalized	60	65	95-100	105
Hard. & Temp	—	170[b], 120[c]	170[d], 115[e]	215[f], 142[g]
Elong (in 2 in.), %				
Normalized	30	27	18-22	13
Hard. & Temp	—	16[b], 22[c]	15[d], 22[e]	10[f], 16[g]
Red. of Area, %				
Normalized	60	57	44-55	33
Hard. & Temp	—	49[b], 63[c]	48[d], 63[e]	40[f], 54[g]
Hardness (Brinell)				
Normalized	185	207	241-280	311
Hard. & Temp	—	375[b], 270[c]	385[d], 255[e]	444[f], 331[g]
Impact Str (Izod), ft-lb				
Normalized	—	63	17	7
Hard. & Temp	—	25[b], 100[c]	16[d], 80[e]	12[f], 53[g]
Fatigue Str	Proportional to tensile strength in same ratio as in other low alloy steels. Below 400 Bhn the ratio is about 50%; at higher hardnesses, 45-48%			
THERMAL TREATMENT				
Normalizing Temp, F	1550-1600	1600-1700	1600-1650	1550-1650
Hardening Temp, F	—	1550-1600	1550-1600	1475-1525
Tempering Temp, F	—	400-1200	400-1300	400-1300
FABRICATING PROPERTIES				
Machinability Index[a]	—	60	62	45
Weldability	Weldable by all commercial welding procedures, difficulty of welding increases with carbon content			
CORROSION RESISTANCE	Similar to carbon steels			
AVAILABLE FORMS	Available in all standard mill forms			
USES	Arbors, gears, camshafts	Shafts, bushings, axles, structural plates, aircraft fuselage, tubing, gas cylinders	Gears, shafts, machine tool parts, bolts, crankshafts	Gears, shafting, wrenches, clutch parts, valve seats, connecting rods

[a] Based on AISI B1112 steel = 100.
[b] Quenched from 1550-1600 F in water; tempered at 800 F.
[c] Quenched from 1550-1600 F in water; tempered at 1200 F.
[d] Quenched from 1550 F in oil; tempered at 800 F.
[e] Quenched from 1550 F in oil; tempered at 1200 F.
[f] Quenched from 1525 F in oil; tempered at 800 F.
[g] Quenched from 1525 F in oil; tempered at 1200 F.

Low Alloy Steels (43xx)—Wrought

AISI Type →	4317	4320	4337	4340
COMPOSITION, %	C 0.15–0.20, Mn 0.45–0.65, Ni 1.65–2.00, Cr 0.40–0.60, Mo 0.20–0.30	C 0.17–0.22, Mn 0.45–0.65, Ni 1.62–2.00, Cr 0.40–0.60, Mo 0.20–0.30	C 0.35–0.40, Mn 0.60–0.80, Ni 1.65–2.00, Cr 0.70–0.90, Mo 0.20–0.30	C 0.38–0.43, Mn 0.60–0.80, Ni 1.65–2.00, Cr 0.70–0.90, Mo 0.20–0.30
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Melting Point, F	2750	2750	2740	2740
Ther Cond (120 F), Btu/hr/sq ft/°F/ft	21.7	21.7	21.7	21.7
Coef of Ther Exp, per °F				
0 to 200 F	6.3×10^{-6}	6.3×10^{-6}	6.3×10^{-6}	6.3×10^{-6}
0 to 1200 F	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}
Spec Ht, Btu/lb/°F	0.107	0.107	0.107	0.107
Elec Res, microhm-cm				
120 F	30	30	30	30
570 F	48	48	48	48
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$29\text{-}30 \times 10^{6}$	$29\text{-}30 \times 10^{6}$	$29\text{-}30 \times 10^{6}$	$29\text{-}30 \times 10^{6}$
Ten Str, 1000 psi				
As Rolled	122	134	180	192
Annealed	95	98	115	119
Hard & Temp[a]	160[b]	180[b]	140[c], 210[d]	150[c], 220[d]
Yld Str, 1000 psi				
As Rolled	99	102	141	147
Annealed	77	89	96	99
Hard & Temp[a]	130[b]	154[b]	120[c], 190[d]	130[c], 200[d]
Elong (in 2 in.), %				
As Rolled	19	17	11	9
Annealed	25	23	19	17
Hard. & Temp[a]	17[b]	15[b]	21[c], 14[d]	19[c], 12[d]
Red of Area, %				
As Rolled	47	43	21	19
Annealed	54	52	45	43
Hard. & Temp[a]	57[b]	50[b]	59[c], 50[d]	57[c], 48[d]
Hardness (Brinell)				
As Rolled	250	265	365	380
Annealed	185	195	230	240
Hard & Temp[a]	320[b]	360[b]	300[c], 435[d]	310[c], 445[d]
Impact Str (Izod, hard. & temp[a]), ft-lb	40[b]	32[b]	75[c], 18[d]	73[c], 16[d]
FABRICATING PROPERTIES				
Annealing Temp, F	1550-1600	1550-1600	1550-1600	1550-1600
Hardening Temp, F	1525-1575	1525-1575	1475-1550	1475-1550
Max Hot Working Temp, F	2300	2300	2300	2300
Machinability Index[e]	55	51	51	51
Weldability	All grades readily weldable by oxyacetylene, inert arc and electrical resistance methods. Preheating desirable for AISI 4337 and 4340			
CORROSION RESISTANCE	Better corrosion resistance than plain carbon steels			
AVAILABLE FORMS	Usually supplied as bars, forgings, tubing and billets, but can be obtained in all steel mill forms			
USES	Heavy duty carburized parts such as gears, bearing races		Heavy duty, high strength applications, particularly in sections over about 1½ in. thick. Gears, aircraft tubing, shafts, heavy forgings, churn drills	

[a] Properties after heat treatment are based upon oil quench and 1-in. round bars.
[b] These are core properties of pseudo-carburized 1-in. bars, tempered at 300 F.
[c] Tempered at 1200 F. [d] Tempered at 800 F. [e] Based on AISI B1112 steel = 100.

Low Alloy Steels (46xx)—Wrought

AISI Type→	4615	4620	4640	4650
COMPOSITION, %	C 0.13-0.18, Mn 0.45-0.65, Ni 1.65-2.00, Mo 0.15-0.25, Si 0.25 max	C 0.17-0.22, Mn 0.45-0.65, Ni 1.65-2.00, Mo 0.20-0.30, Si 0.25 max	C 0.38-0.43, Mn 0.60-0.80, Ni 1.65-2.00, Mo 0.20-0.30, Si 0.25 max	C 0.48-0.55, Mn 0.60-0.80, Ni 1.65-2.00, Mo 0.20-0.30, Si 0.25 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.28	0.28	0.28	0.28
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (0-200 F), per °F	6.3×10^{-6}	6.3×10^{-6}	6.3×10^{-6}	6.3×10^{-6}
Spec Ht, Btu/lb/°F	0.10-0.11	0.10-0.11	0.10-0.11	0.10-0.11
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29×10^6	29×10^6	29×10^6	29×10^6
Ten Str, 1000 psi				
Normalized	80	88	123	130
Hard. & Temp	100[a]	130[a]	185[b], 120[c]	200[b], 130[c]
Yld Str, 1000 psi				
Normalized	60	63	87	93
Hard. & Temp	75[a]	95[a]	160[b], 102[c]	180[b], 112[c]
Elong (in 2 in.), %				
Normalized	31	30	18	12
Hard. & Temp	18[a]	21[a]	14[b], 23[c]	18[b], 22[c]
Red. of Area, %				
Normalized	60	60	50	38
Hard. & Temp	52[a]	65[a]	52[b], 60[c]	55[b], 60[c]
Hardness (Brinell)				
Normalized	160	178	248	260
Hard. & Temp	—	—	390[b], 255[c]	400[b], 280[c]
Impact Str (Izod), ft-lb				
Normalized	—	—	31	—
Hard. & Temp	42[a]	68[a]	25[b], 60[c]	23[b], 60[c]
Fatigue Str	Proportional to tensile strength in same ratio as in other alloy steels. Below 400 Bhn ratio is about 50%; at higher hardnesses, about 45 to 48%			
THERMAL TREATMENT				
Normalizing Temp, F	1625-1650	1625-1650	1600-1750	1600-1750
Hardening Temp, F	1525-1575	1525-1575	1475-1525	1450-1500
Tempering Temp, F	300	300	400-1200	400-1200
FABRICATING PROPERTIES				
Machinability Index[d]	58-60	58-60	55	45
Weldability	Weldable by all commercial welding procedures, difficulty of welding increases with carbon content			
CORROSION RESISTANCE	Similar to carbon steels			
AVAILABLE FORMS	Available in all standard mill forms			
USES	Arbors, ball bearings, gears, camshafts, spindles, valve tappets		Leaf and coil springs, shovels, gears, shafts, drill stems	Gears, pinions, shafts

[a] Typical core properties pseudo-carburized 1650-1700 F, oil quenched from 1475 F, tempered at 300 F.
[b] Norm at 1650 F, reheated to 1475 F, oil quenched, tempered at 800 F.
[c] Norm at 1650 F, reheated to 1475 F, oil quenched, tempered at 1200 F.
[d] Based on AISI B1112 steel = 100.

Low Alloy Steels (48xx)—Wrought

AISI Type ➡	4815	4817	4820
COMPOSITION, %	C 0.13–0.18, Mn 0.40–0.60, Si 0.20–0.35, Ni 3.25–3.75, Mo 0.20–0.30	C 0.15–0.70, Mn 0.40–0.60, Si 0.20–0.35, Ni 3.25–3.75, Mo 0.20–0.35	C 0.18–0.23, Mn 0.50–0.70, Si 0.20–0.35, Ni 3.25–3.75, Mo 0.20–0.30
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.283	0.283	0.283
Melting Temp Range, F	2750	2750	2750
Ther Cond (75 F), Btu/hr/sq ft/°F/ft	260	260	260
Coef of Ther Exp, per °F			
0 to 200 F	6.8×10^{-6}	6.8×10^{-6}	6.8×10^{-6}
0 to 1200 F	8.6×10^{-6}	8.6×10^{-6}	8.6×10^{-6}
Spec Ht, Btu/lb/°F	—	—	—
Elec Res (68 F), microhm-cm	30	30	30
Magnetic?	Yes	Yes	Yes
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	30×10^{6}	30×10^{6}	30×10^{6}
Tensile Strength, 1000 psi			
Annealed	85	94	98
Normalized	92	105	109
Hard. & Temp[a]	150	—	—
Yield Strength (0.2% offset), 1000 psi			
Annealed	63	65	67
Normalized	80	84	88
Hard. & Temp[a]	125	—	—
Elongation (in 2 in.), %			
Annealed	28	27	27
Normalized	25	23	22
Hard. & Temp[a]	18	15	13
Reduction of Area, %			
Annealed	60	59	59
Normalized	59	59	59
Hard. & Temp[a]	58	52	47
Hardness (Brinell)			
Annealed	192	196	200
Normalized	205	212	220
Hard. & Temp[a]	325	355	380
Impact Strength (Izod), ft-lb			
Annealed	—	68	—
Normalized	—	81	—
Hard. & Temp[a]	44	36	28
FABRICATING PROPERTIES			
Annealing Temp, F	1500–1575	1475–1525	1475–1525
Hardening Temp, F	1450–1500	1450–1500	1425–1475
Tempering Temp, F	300	300	300
Hot Working Temp Range, F	1950–2200	1950–2200	1950–2200
Machinability Index	45	45	45
Weldability	Ordinarily not welded		
CORROSION RESISTANCE	Better corrosion resistance than plain carbon steels		
AVAILABLE FORMS	Billets, bars, tubes, forgings, plates		
USES	Heavy duty gears, rock bits, pump parts, oil well sucker rods, machine tools. Grade selected depends on desired core strength in carburized parts		

[a] Pseudo-carburized at 1750 F, oil quenched, tempered at 300 F.

Low Alloy Steels (51xx)—Wrought

AISI Type ➡	5120	5130	5140	5150
COMPOSITION, %	C 0.17-0.22, Mn 0.70-0.90, Cr 0.70-0.90	C 0.28-0.33, Mn 0.70-0.90, Cr 0.80-1.10	C 0.38-0.43, Mn 0.70-0.90, Cr 0.70-0.90	C 0.48-0.53, Mn 0.70-0.90, Cr 0.70-0.90
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Melting Point, F	2760	2745	2730	2720
Ther Cond (32-212 F), Btu/hr/sq ft/°F/ft	—	34.2	27	—
Coef of Ther Exp (100-518 F), per °F	7.2 x 10^{-6}	7.2 x 10^{-6}	7.6 x 10^{-6}	7.4 x 10^{-6}
Spec Ht, Btu/lb/°F	0.10-0.11	0.10-0.11	0.10-0.11	0.10-0.11
Elec Res, microhm-cm				
68 F	—	21.0	21.0	—
212 F	—	25.9	—	—
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29-30 x 10^6	29-30 x 10^6	29-30 x 10^6	29-30 x 10^6
Ten Str, 1000 psi				
Annealed	87	—	90	90
Hot Rolled	—	—	115	—
Normalized	—	—	110	135
Hard. & Temp	143[a], 121[b], 136[c]	189[d], 115[e]	190[d], 124[e]	224[d], 142[e]
Yld Str (0.2% offset), 1000 psi				
Annealed	70	—	56	58
Hot Rolled	—	—	75	—
Normalized	—	—	71	120
Hard. & Temp	114[a], 92[b], 110[c]	175[d], 100[e]	170[d], 100[e]	208[d], 130[e]
Elongation (in 2 in.), %				
Annealed	23	—	27	23
Hot Rolled	—	—	20	—
Normalized	—	—	23	13
Hard. & Temp	13.5[a], 14[b], 16[c]	13[d], 23[e]	13[d], 22[e]	10[d], 18[e]
Red. of Area, %				
Annealed	60	—	62	54
Hot Rolled	—	—	57	—
Normalized	—	—	61	37
Hard. & Temp	45[a], 41[b], 45[c]	51[d], 63[e]	43[d], 64[e]	40[d], 55[e]
Hardness (Rockwell, Brinell)				
Annealed	179	—	183	183
Hot Rolled	155	—	223	—
Normalized	202	—	213	293
Hard. & Temp	302[a], 260[b], 285[c]	380[d], 240[e]	375[d], 241[e]	444[d], 293[e]
Impact Str (Izod, hard. & temp), ft-lb	6.0[a], 8.0[b], 15.0[c]	—	16[d], 78[e]	—
FABRICATING PROPERTIES				
Annealing Temp, F	1600	1550-1700	1525-1550	1450-1725
Hardening Temp, F	1600	1550-1600	1500-1550	1470-1525
Normalizing Temp, F	1650-1750	1600-1725	1550-1650	1600-1750
Hot Working Temp Range, F	2000-2250	2000-2250	2000-2250	2000-2250
Machinability Index, %	65	67	60	55
Weldability	Readily weldable by oxyacetylene, inert arc and electrical resistance methods; shielded arc carbon-molybdenum/steel electrodes are recommended			
CORROSION RESISTANCE	Better corrosion resistance than plain carbon steels			
AVAILABLE FORMS	Bars, rods, tubing, forgings, castings			
USES	Transmission gears, steering knuckles	Side gears	Transmission gears, shafts, axles, steering knuckles, thrust washers, springs, sleeve wheels, wrenches	Coil springs, flat springs ⅛ in. and heavier

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[a] Pseudo-carburized at 1680 F, oil quenched, tempered at 300 F.
[b] Same as (a) but pot cooled and reheated at 1425 F.
[c] Same as (a) but pot cooled and reheated at 1525 F.
[d] Norm. at 1625 F, reheated to 1550 F, oil quenched (5130 is water quenched), tempered at 800 F.
[e] Same as (d) but tempered at 1200 F.
[f] Oil quenched from 1525 F, tempered at 800 F.
[g] Oil quenched from 1525 F, tempered at 1200 F.

Low Alloy Steels (61xx)—Wrought

AISI Type ➔	6120	6145	6150	6152
COMPOSITION, %	C 0.17–0.22, Mn 0.70–0.90, Si 0.20–0.35, Cr 0.70–0.90, V 0.10 min	C 0.43–0.48, Mn 0.70–0.90, Si 0.20–0.35, Cr 0.80–1.10, V 0.15 min	C 0.48–0.53, Mn 0.70–0.90, Si 0.20–0.35, Cr 0.80–1.10, V 0.15 min	C 0.48–0.53, Mn 0.70–0.90, Si 0.20–0.35, Cr 0.80–1.10, V 0.10 min
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	21	21	21	21
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$29\text{-}30 \times 10^{6}$	$29\text{-}30 \times 10^{6}$	$29\text{-}30 \times 10^{6}$	$29\text{-}30 \times 10^{6}$
Ten Str, 1000 psi				
Normalized	85	115	158	—
Hard. & Temp	105[a], 125[b]	176[c], 136[d]	187[c], 144[d]	151[e]
Yld Str, 1000 psi				
Normalized	50	75	88	—
Hard. & Temp	71[a], 94[b]	169[c], 130[d]	179[c], 138[d]	125[e]
Elong (in 2 in.), %				
Normalized	35	24	23	—
Hard. & Temp	19[a], 21[b]	16[c], 22[d]	13[c], 18[d]	16[e]
Red. of Area, %				
Normalized	67	64	62	—
Hard. & Temp	37[a], 56[b]	52[c], 58[d]	42[c], 53[d]	54[e]
Hardness (Brinell)				
Normalized	185	216	240	—
Hard. & Temp	—	429[c], 311[d]	444[c], 363[d]	—
Impact Str (Izod), ft-lb				
Normalized	102	31	—	—
Hard. & Temp	25[a], 28[b]	20[c], 87[d]	13[c], 63[d]	—
Fatigue Str	Endurance limit is proportional to tensile strength in the same ratio as in other low alloy steels. Below 400 Bhn the ratio is about 50%, and at higher hardnesses it is 45–48% of the tensile strength			
THERMAL TREATMENT				
Normalizing Temp, F	1650–1700	1600–1650	1600–1650	1600–1650
Hardening Temp, F	1600–1650	1550–1650	1550–1650	1550–1650
Tempering Temp, F	375–1200	450–1200	450–1200	450–1200
FABRICATING PROPERTIES				
Formability	Similar to other alloy steels of low chromium content. Hot working temperatures are limited not by brittle ranges but by degree of malleability required for the specific application. Because of stiffening, cold working is somewhat more difficult than with carbon steels			
Machinability Index[f]				
Hot Rolled	27	22	24	24
Normalized	46	27	26	26
Weldability	Weldable by all commercial welding procedures, the difficulty of welding increasing with carbon content. Preheating and postheating treatments sometimes necessary			
CORROSION RESISTANCE	Similar to carbon steels. Chromium content too low to have appreciable influence on rate of corrosion			
AVAILABLE FORMS	Available in all standard mill forms			
USES	Carburized gears, shafts, piston pins and bushings. Nitrided and carbonitrided parts	Crankshafts, connecting rods, bevel and spur gears, shafts, springs, axles, pins		

[a] Typical core properties: carburized 16 hr at 1680 F, pot cooled, oil quenched from 1425 F, tempered at 300 F.
[b] Same as a but oil quenched from 1525 F.
[c] Normalized at 1600 F, oil quenched from 1575 F, tempered at 1000 F.
[d] Same as c but tempered at 1200 F.
[e] Oil quenched from 1575 F, tempered at 1000 F.
[f] Based on AISI B1112 steel = 100.

Low Alloy Steels (86xx, 87xx)—Wrought

AISI Type ➡	8620, 8720	8630	8640, 8740	8650, 8750
COMPOSITION, %	C 0.18–0.23, Mn 0.70–0.90, Ni 0.40–0.70, Cr 0.40–0.60, Mo 0.15–0.25 (8620), 0.20–0.30 (8720)	C 0.28–0.33, Mn 0.70–0.90, Ni 0.40–0.70, Cr 0.40–0.60, Mo 0.15–0.25	C 0.38–0.43, Mn 0.75–1.00, Ni 0.40–0.70, Cr 0.40–0.60, Mo 0.15–0.25 (8640), 0.20–0.30 (8740)	C 0.48–0.53, Mn 0.75–1.00, Ni 0.40–0.70, Cr 0.40–0.60, Mo 0.15–0.25 (8650), 0.20–0.30 (8750)
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Melting Point, F	2755	2750	2745	2745
Ther Cond (120 F), Btu/hr/sq ft/°F/ft	21.7	21.7	21.7	21.7
Coef of Ther Exp, per °F				
0 to 200 F	6.45 x 10^{-6}	6.45 x 10^{-6}	6.45 x 10^{-6}	6.45 x 10^{-6}
0 to 1200 F	8.25 x 10^{-6}	8.25 x 10^{-6}	8.25 x 10^{-6}	8.25 x 10^{-6}
Spec Ht, Btu/lb/°F	0.107	0.107	0.107	0.107
Elec Res, microhm-cm				
120 F	30	30	30	30
570 F	48	48	48	48
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29–30 x 10^{6}	29–30 x 10^{6}	29–30 x 10^{6}	29–30 x 10^{6}
Ten Str, 1000 psi				
Normalized	94	112	130	149
As Rolled	91	109	126	143
Annealed	77	86	95	105
Hard. & Temp (800 F)[a]	122, 96[b]	162, 111[b]	208, 130[b]	214, 136[b]
Yld Str, 1000 psi				
Normalized	61	73	85	96
As Rolled	65	78	90	101
Annealed	51	58	63	70
Hard. & Temp (800 F)[a]	98, 76[b]	142, 92[b]	183, 110[b]	194, 116[b]
Elong (in 2 in.), %				
Normalized	29	23	18	11
As Rolled	29	25	20	17
Annealed	32	29	27	23
Hard. & Temp (800 F)[a]	21, 26[b]	14, 23[b]	13, 21[b]	12, 21[b]
Red. of Area, %				
Normalized	61	52	45	36
As Rolled	56	48	40	31
Annealed	64	59	55	50
Hard. & Temp (800 F)[a]	63, 70[b]	54, 66[b]	43, 60[b]	41, 61[b]
Hardness (Brinell)				
Normalized	190	225	262	300
As Rolled	185	220	244	290
Annealed	163	174	193	210
Hard. & Temp (800 F)[a]	245, 193[b]	325, 225[b]	420, 262[b]	423, 271[b]
Impact Str (Izod, hard. & temp at 800 F), ft-lb[a]	76, 105[b]	42, 91[b]	18, 68[b]	—
FABRICATING PROPERTIES				
Annealing Temp, F	1550–1600	1550–1600	1550–1600	1550–1600
Hardening Temp, F	1525–1575	1525–1575	1500–1550	1475–1550
Max Hot Working Temp, F	2200	2200	2200	2150
Machinability Index[c]	57[d]	61[e]	55[e]	45[e]
Weldability	Readily weldable by oxyacetylene, inert arc and electrical resistance methods. Preheating desirable for grades with more than 0.30% carbon content			
CORROSION RESISTANCE	Better corrosion resistance than plain carbon steels			
AVAILABLE FORMS	Usually supplied as bars, forgings, tubing or billets; sometimes in other steel mill forms			
USES	Medium duty carburized parts such as gears, cams, bearing races		Medium duty, high strength applications, particularly in sections not over approx 2 in. thick. Gears, bolts, aircraft tubing, hand tools, shafts, forgings	

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[a] Properties after heat treatment are based upon an oil quench and 1-in. round bars.
[b] Tempered at 1200 F.
[c] Based on AISI B1112 steel = 100.
[d] As rolled.
[e] Annealed.

Low Alloy Steels (92xx, 94xx)—Wrought

AISI Type ➡	9255	9261	9440	9450
COMPOSITION, %	C 0.50–0.60, Mn 0.70–0.95, Si 1.80–2.20	C 0.55–0.65, Mn 0.75–1.00, Si 1.80–2 20, Cr 0.10–0.25	C 0.38–0.43, Mn 0.90–1.20, Si 0.20–0.35, Ni 0.30–0.60, Cr 0.30–0.50, Mo 0.08–0.15	C 0.43–0.48, Mn 1.00–1.30, Si 0.20–0.35, Ni 0.30–0.60, Cr 0.30–0.50, Mo 0.08–0.15
PHYSICAL PROPERTIES				
Density, lb/cu in	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.1 x 10^{-6}	8.1 x 10^{-6}	8.1 x 10^{-6}	8.1 x 10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.11–0.12	0.11–0.12
Elec Res (68 F), microhm-cm	19	20	20	20
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29 x 10^6	29 x 10^6	29 x 10^6	29 x 10^6
Ten Str, 1000 psi				
Normalized	132[a]	150[c]	115[e]	158[e]
Hard. & Temp (800 F)	232[b]	258[d]	192[f]	210[g]
Hard. & Temp (1200 F)	144[b]	148[d]	120[f]	132[g]
Yld Str, 1000 psi				
Normalized	90	80	74	110
Hard. & Temp (800 F)	215	226	179	192
Hard. & Temp (1200 F)	118	125	102	120
Elong (in 2 in.), %				
Normalized	18	15	24	15
Hard. & Temp (800 F)	9	10	15	12
Hard. & Temp (1200 F)	20	18	23	20
Red. of Area, %				
Normalized	38	30	50	30
Hard. & Temp (800 F)	21	30	56	48
Hard. & Temp (1200 F)	42	40	67	57
Hardness (Brinell)				
Normalized	277	311	235	331
Hard. & Temp (800 F)	477	514	388	429
Hard. & Temp (1200 F)	285	311	248	285
Impact Str (Izod), ft-lb				
Normalized	12	5	48	8
Hard. & Temp (800 F)	6	12	35	14
Hard. & Temp (1200 F)	22	35	99	72
THERMAL TREATMENT				
Normalizing Temp, F	1625–1675	1600–1650	1575–1625	1575–1625
Hardening Temp, F	1500–1650	1500–1650	1500–1550	1500–1550
FABRICATING PROPERTIES				
Hot Working Temp Range, F	1750–2175	1750–2175	1750–2175	1750–2175
Machinability Index (AISI B1112 steel = 100)	38	36	42	40
Weldability	Welding not normally recommended because high carbon and silicon contents introduce difficulty		High carbon content introduces difficulty in welding. With special techniques and electrodes, satisfactory arc welds can be made	
CORROSION RESISTANCE	Better than plain carbon steels in industrial atmosphere and about the same when continuously exposed to moisture. If salts are present, corrosion is increased. Attacked readily by acids, but resistant to alkalis at ordinary temperatures			
AVAILABLE FORMS	Billets, bars, forgings			
USES	Coil and flat springs, lock washers, axes, chisels, hand tools, diesel engine connecting rod bolts, collets for machine tools		Not in general use today. Formerly used for automotive, diesel engine and aircraft parts; bolts; chain; gears	

[a] Normalized at 1650 F.

[b] Normalized at 1650 F, reheated to 1625 F, quenched in agitated oil.

[c] Normalized at 1600 F.

[d] Normalized at 1600 F, reheated to 1575 F, quenched in agitated oil.

[e] Normalized at 1600 F.

[f] Normalized at 1600 F, reheated to 1525 F, quenched in agitated oil.

[g] Normalized at 1600 F, reheated to 1500 F, quenched in agitated oil.

Nitriding Steels—Wrought

Nitralloy Type ➡	135	135, Modified	N	EZ	GR
COMPOSITION, %	C 0.30–0.40, Mn 0.40–0.70, Si 0.20–0.40, Cr 0.90–1.40, Al 0.85–1.20, Mo 0.15–0.25	C 0.38–0.45, Mn 0.40–0.70, Si 0.20–0.40, Cr 1.40–1.80, Al 0.85–1.20, Mo 0.30–0.45	C 0.20–0.27, Mn 0.40–0.70, Si 0.20–0.40, Cr 1.00–1.50, Al 0.85–1.20, Mo 0.20–0.30, Ni 3.25–3.75	C 0.30–0.40, Mn 0.50–1.10, Si 0.20–0.40, Cr 1.00–1.50, Al 0.85–1.20, Mo 0.15–0.25, Se 0.15–0.25	C 1.25–1.50, Mn 0.40–0.60, Si 1.25–1.50, Cr 0.20–0.40, Al 1.00–1.50, Mo 0.20–0.30
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	30	30	30	30	30
Coef of Ther Exp (32-932 F), per °F	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}
Spec Ht, Btu/lb/°F	0.11–0.12	0.11–0.12	0.11–0.12	0.11–0.12	0.11–0.12
Elec Res (68 F), microhm-cm	27–29	27–29	27–29	27–29	27–29
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$
Ten Str (hard. & temp), 1000 psi	138[a], 121[b]	159[a], 145[b]	132[c], 190[d]	126[a]	108[e]
Yld Str (hard. & temp), 1000 psi	120[a], 103[b]	141[a], 125[b]	114[c], 180[d]	90[a] [f]	84[e]
Elong (in 2 in., hard. & temp), %	20[a], 23[b]	18[a], 20[b]	22[c], 15[d]	17[a]	17[e]
Red. of Area (hard. & temp), %	58[a], 62[b]	56[a], 64[b]	59[c], 43[d]	44[a]	19[e]
Hardness (Brinell, hard. & temp)	280[a], 230[b]	320[a], 285[b]	277[c], 415[d]	255[a]	—
	Cases produced by nitriding these steels will have hardnesses in the range Rockwell 15N 94 to 95, excepting case on Nitralloy N which will range from about Rockwell 15N 92 to 93				
Impact Str (Izod, hard. & temp), ft-lb	65[a], 80[b]	—	—	—	—
Endurance Limit, 1000 psi[g]	—	45[g1], 24[g2], 90[g3], 80[g4]	—	—	—
THERMAL TREATMENT					
Annealing Temp, F	1650–1700	1650–1700	1500–1550[h]	1650–1700	—
Quenching Temp, F	1700–1750	1700–1750	1625–1675	1700–1750	1625–1675
Tempering Temp, F	1100–1300	1100–1300	1100–1300	1100–1300	1100–1300
Nitriding Temp, F	930–1050 for periods ranging to 100 hr; 24 to 48-hr treatments are most widely used				
FABRICATING PROPERTIES					
Hot Working Temp Range, F	1950–2200	1950–2200	1950–2200	1950–2200	1950–2200
Weldability	Can be welded by atomic hydrogen process using Nitralloy welding rod; also flash welding				
CORROSION RESISTANCE	Provided the outer skin or white layer is not removed, the nitrided case is resistant to alkalis, crude oil, natural gas combustion products, tap water and unagitated salt water. Case is attacked by mineral acids. Removal of the white layer greatly reduces resistance to attack				
USES	Most uses based on resistance to wear. Cylinder liners and barrels in aircraft engines, bushings, shafts, piston pins, spindles and thread guides, cams and camshafts, rubber and paper mill rolls				

[a] Core properties; oil quenched from 1700 F, tempered at 1200 F.

[b] Core properties; oil quenched from 1700 F, tempered at 1300 F.

[c] Core properties; oil quenched from 1650 F, tempered at 1200 F, before nitriding.

[d] Core properties; oil quenched from 1650 F, tempered at 1200 F, after nitriding

[e] Core properties; oil quenched from 1650 F, tempered 5 hr at 1375 F.

[f] Proportional limit.

[g] Heat treated to 269 Bhn and tested (g1) unnitrided, unnotched; (g2) unnitrided with V notch; (g3) nitrided, unnotched; (g4) nitrided with V notch.

[h] Must be cooled rapidly below 1150 F to avoid precipitation hardening.

Austenitic Stainless Steels—Wrought

AISI Type →	201	202
COMPOSITION, %	C 0.15 max, Mn 5.5–7.5, Cr 16.0–18.0, Ni 3.5–5.5, N 0.25 max	C 0.15 max, Mn 7.5–10.0, Cr 17.0–19.0, Ni 4.0–6.0, N 0.25 max
PHYSICAL PROPERTIES		
Density, lb/cu in	0.28	0.28
Ther Cond (68–212 F), Btu/hr/sq ft/°F/ft	9.4	9.4
Coef of Ther Exp, per °F		
32 to 200 F	8.78 x 10^{-6}	—
32 to 600 F	9.7 x 10^{-6}	10.2 x 10^{-6}
32 to 900 F	10.1 x 10^{-6}	10.6 x 10^{-6}
32 to 1400 F	—	11.3 x 10^{-6}
Specific Heat, Btu/lb/°F	0.12	0.12
Electrical Resistivity (68 F), microhm-cm	69	69
Magnetic?	No	No
Magnetic Permeability (max)	1.02	1.02
MECHANICAL PROPERTIES		
Mod of Elast in Tension, psi	28.6 x 10^{6}	28 x 10^{6}
Tensile Strength, 1000 psi		
Annealed[a]		
Tested at Rm Temp	115, 114, 95[b]	105, —
Tested at 1200 F	—, 50	—
Tested at 1400 F	—, 37	—
Cold Worked[c]		
Quarter Hard	125	—
Half Hard	150	—
Yield Strength, 1000 psi		
Annealed[a]		
Tested at Rm Temp	55, 53, 47[b]	55, —
Tested at 1200 F	—, 21	—
Tested at 1400 F	—, 19	—
Cold Worked[c]		
Quarter Hard	75	—
Half Hard	110	—
Elongation (in 2 in.), %		
Annealed[a]		
Tested at Rm Temp	55, 57, 60[b]	55, —
Tested at 1200 F	—, 36	—
Tested at 1400 F	—, 38	—
Cold Worked[c]		
Quarter Hard	25	—
Half Hard	15	—
Hardness (Rockwell, annealed)	B90	B90
Rupture Stress (annealed, 1000 hr), 1000 psi		
Tested at 1200 F	22.0	—
Tested at 1400 F	7.0	—
THERMAL TREATMENT		
Annealing Temp, F	1850–2050	1850–2050
FABRICATING PROPERTIES		
Hot Working Temp Range, F	2100–2250	2100–2250
Formability	Moderate; similar to type 301	Good; similar to type 302
Machinability	Good	Good
Weldability	Similar to type 301; normally spot welded	Similar to type 302
CORROSION RESISTANCE	Good; similar to type 301	Good; similar to types 302, 304
AVAILABLE FORMS	Sheet, strip, some bar	Rod, bar, sheet, strip, plate
USES	Alternate for type 301, but tests should be made if severe corrosion conditions exist	Alternate for type 302, but tests should be made if severe corrosion conditions exist

[a] Where two values are given, they represent sheet and bar respectively.

[b] Welded and annealed.

[c] Minimum value for sheet tested at room temperature.

Austenitic Stainless Steels—Wrought

AISI Type ➜	301	302	303	304, 304 ELC
COMPOSITION, %	C 0.08–0.20, Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 16–18, Ni 6–8	C 0.08–0.20, Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 17–19, Ni 8–10	C 0.15 max, Mn 2 max, P, S or Se 0.07 min, Si 1 max, Cr 17–19, Ni 8–10, Mo or Zr 0.60 max	C 0.08 max (304) or 0.03 max (304 ELC), Mn 2 max, Si 1 max, P 0.04 max, S 0.030 max, Cr 18–20, Ni 8–11
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.29	0.29	0.29	0.29
Melting Point Range, F	2550–2590	2550–2590	2550–2590	2550–2650
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.4	9.4	9.4	9.4
Coef of Ther Exp (32–212 F), per °F	9.5×10^{-6}[a]	9.9×10^{-6}	9.9×10^{-6}	9.9×10^{-6}
Spec Ht (32–212 F), Btu/lb/°F	0.12	0.12	0.12	0.12
Elec Res (68 F), microhm-cm	72	72	72	72
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi	28.0×10^6	28.0×10^6	28.0×10^6	28.0×10^6
Ten Str, 1000 psi				
Annealed	110, 105, —	90, 90, 85	—, —, 90	85, 85, 85
Cold Worked[d]	185, —, —	—, —, 110[c]	—, —, 110[c]	—, —, 110[c]
Yld Str, 1000 psi				
Annealed	40, 40, —	40, 35, 35	—, —, 35	35, 30, 35
Cold Worked[d]	140, —, —	—, —, 75[c]	—, —, 75[c]	—, —, 75[c]
Elong (in 2 in.), %				
Annealed	60, 55, —	50, 60, 60	—, —, 50	50, 60, 60
Cold Worked[d]	8-9, —, —	—, —, 35[c]	—, —, 30[c]	—, —, 60
Red. of Area, %				
Annealed	—, 70, —	—, 70, 70	—. —, 55	—, 70, 70
Cold Worked	—	—, —, 60[c]	—, —, 50[c]	—
Hardness[e]				
Annealed	R_B85, —, —	R_B85, R_B80, 150	—, —, 160	R_B80, 150, 150
Cold Worked	R_B41, —, —	—, —, 240[c]	—, —, 240[c]	—, —, 240[c]
Impact Str (Izod), ft-lb				
Annealed	—, 165, —	—, 110, 110	—, —, 80	—, 110, 110
Cold Worked	—	—	—	—, —, 90[c]
Endurance Limit, 1000 psi				
Annealed	35, 39, —	—, —, 34	—, —, 35	35, 35, 34
Cold Worked	80, —, —	—	—	—
Creep Str (1% ext in 1000 hr), psi				
1000 F	—	17,000	—	17,000
1300 F	—	4,000	—	4,000
1500 F	—	1,200	—	1,200
FABRICATING PROPERTIES				
Annealing Temp, F[f]	1850–2050	1900–2050	1850–2050	1900–2050
Forging Temp (start), F[g]	2200	2100	2100	2200
Machinability	—	Fair; tough	Good; about 65% of screw stock	Fair; tough
Weldability	Very good	Not recommended; may crack		Very good
CORROSION RESISTANCE	Very good atmosphere resistance; slightly less than type 302	Excellent atmosphere resistance; also resists food products, acids and other chemicals	Very good atmosphere resistance; some resistance sacrificed for better machinability	Excellent atmosphere resistance; slightly better than type 302
AVAILABLE FORMS	Sheet, strip, wire	Sheet, strip, plate, bar, wire	Bar, wire	Sheet, strip, plate, bar, wire
USES	Lightweight, high strength applications; transportation equipment, roof drainage and trim	General purpose	General purpose, but where better machinability (than type 302) is required	Light welded construction where corrosive conditions are not too severe

[a] For 32-600 F range.
[b] Where three values are given, they represent sheet, plate and bar in that order.
[c] Cold drawn, high tensile 1½-in. dia bar.
[d] Minimum value at full hard temper.
[e] Values are Brinell except where Rockwell scale is noted.
[f] Cool rapidly after anneal.
[g] Finish forging all grades at 1700 F or above.

continued on next page

Austenitic Stainless Steels—Wrought

AISI Type ➜	309	310	316, 316 ELC	321
COMPOSITION, %	C 0.20 max, Mn 2 max, P 0.04 max, S 0.03 max, Si 1 max, Cr 22-24, Ni 12-15	C 0.25 max, Mn 2 max, P 0.04 max, S 0.03 max, Si 1.5 max, Cr 24-26, Ni 19-22	C 0.10 max (316), C 0.03 max (316 ELC), Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 16-18, Ni 10-14, Mo 2-3	C 0.08 max, Mn 2 max, Si 1 max, P 0.04 max S 0.03 max, Cr 17-19, Ni 8-11, Ti 5 x C
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.29	0.29	0.29	0.29
Melting Point Range, F	2550–2650	2550–2650	2500–2550	2550–2600
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	8	8	9.4	9.3
Coef of Ther Exp (32–600 F), per °F	9.3×10^{-6}	9.0×10^{-6}	9.0×10^{-6}	9.5×10^{-6}
Spec Heat (32–212 F), Btu/lb/°F	0.12	0.12	0.12	0.12
Elec Res (68 F), microhm-cm	78	78	74	72
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi	29.0×10^6	2.9×10^6	28.0×10^6	28.0×10^6
Ten Str (ann.), 1000 psi	90, 95, 95	95, 95, 95	90, 85, 80	90, 85, 85
Yld Str (ann.), 1000 psi	45, 40, 40	45, 45, 45	40, 35, 30	35, 30, 35
Elong (in 2 in., ann.), %	45, 45, 45	45, 50, 50	50, 55, 60	50, 55, 55
Red. of Area (ann.), %	—, —, 65	—, —, —	—, —, 70	—, —, 65
Hardness (ann.)[e]	R_B85, 170, 160	R_B85, —, R_B89	R_B85, 150, 150	R_B80, 160, 150
Impact Str (Izod, ann.), ft-lb.	—, —, 110	—, —, 85	—, —, 110	—, —, 110
Endurance Limit (ann.), 1000 psi	—	—, —, —	39, 39, 38	—, —, 38
Creep Str (1% ext in 10,000 hr), psi				
1000 F	15,900	17,000	25,000	18,000
1300 F	4,500	5,000	7,900	4,500
1500 F	1,000	1,000	2,800	850
FABRICATING PROPERTIES				
Annealing Temp, F	1900-2050	1900-2100	1850–2050	1900–2050
Forging Temp (start), F[g]	2150	2000–2250	2200	2250
Machinability	Fair; tough	Fair; tough	Fair; tough	Fair; tough
Weldability	Good	Good	Very good	Very good
CORROSION RESISTANCE	Excellent atmosphere resistance; better than type 302. Resists destructive heat scaling up to 2000 F	Excellent atmospheric resistance; better than type 309. Resists scaling to 2100 F	Best of any standard stainless steel. Greater resistance than type 302 to reducing acids, sea water and other corrosive media causing pitting type of corrosion. Intergranular corrosion due to welding eliminated in 316 ELC	Excellent atmosphere resistance; similar to type 302. Not subject to harmful carbide precipitation
AVAILABLE FORMS	Sheet, strip, plate, bar, wire	Sheet, strip, plate, bar	Sheet, strip, plate, bar, wire	Sheet, strip, plate, bar wire
USES	Heat resisting applications	Heat exchangers, petroleum refining and chemical processing equipment, gas turbines	Processing equipment exposed to severe corrosive media. Stressed parts that operate at high temperatures	Welded equipment used in the unannealed condition and exposed to corrosive conditions. Equipment that must operate in the sensitization range (800-1650 F)

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[b] Where three values are given, they represent sheet, plate and bar in that order.
[e] Values are Brinell except where Rockwell scale is noted.
[g] Finish forging in all grades at 1700 F or above.

Ferritic Stainless Steels—Wrought

AISI Type ➡	405	430	430F	446
COMPOSITION, %[a]	C 0.08, Mn 1.00, Si 1.00, P 0.04, S 0.03, Cr 11.5–14.5, Al 0.10–0.30	C 0.12, Mn 1.00, Si 1.00, P 0.04, S 0.03, Cr 14.0–18.0	C 0.12, Mn 1.25, P 0.06, S 0.15 min, Cr 14.0–18.0	C 0.20, Mn 1.50, Si 1.00, P 0.04, S 0.03, Cr 23.0–27.0, N 0.25
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.28	0.28	0.28	0.27
Melting Temp Range, F	2700–2790	2600–2750	2600–2750	2600–2750
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	15.1	15.1	12.1
Coef of Ther Exp (32–212 F), per °F	6.0 x 10^{-6}	5.8 x 10^{-6}	5.8 x 10^{-6}	5.8 x 10^{-6}
Spec Ht, Btu/lb/°F	0.11	0.11	0.11	0.12
Elec Res (70 F), microhm-cm	60.0	60.0	60.0	67.0
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29 x 10^6	29 x 10^6	29 x 10^6	29 x 10^6
Ten Str, 1000 psi				
Annealed	65–70	75	80	80–85
Cold Worked	85	75–90	80–90	85
Yld Str (0.2% offset), 1000 psi				
Annealed	35–40	40–45	55	50–55
Cold Worked	70	45–80	55–80	70
Elong (in 2 in.), %				
Annealed	25–30	25–30	25	20–25
Cold Worked	20	15–25	15–25	20
Red. of Area, %				
Annealed	50–60	60–65	60–65	45
Cold Worked	60	55–65	55–65	45
Hardness (Rockwell)				
Annealed	B75–90	B80	B80	B83–B86
Cold Worked	185[b]	B95	B95	B90
Impact Str (Izod, annealed), ft-lb	25[c]	—	—	2
Creep Str (1%, 1000 F), 1000 psi				
10,000 Hr	—	8.5	8.5	6.0
100,000 Hr	—	7.0	7.0	4.2
THERMAL TREATMENT				
Annealing Temp, F	1350–1500	1400–1500	1250–1400	1450–1600
FABRICATING PROPERTIES				
Hot Working Temp Range, F	1950–2050	1900–2050	1950–2100	1950–2050
Machinability	Good	Fair	Excellent	Fair
Weldability	Excellent for fusion welding	Fair; welds are brittle	Not recommended	Fair; great care required because of high Cr content
CORROSION RESISTANCE	Good resistance to weather, water, some chemicals	Excellent resistance to weather, water; good resistance to most chemicals	Very good resistance to weather, water; some resistance sacrificed for better machinability	High resistance to corrosion and scaling; one of the most oxidation resistant steels commercially available
AVAILABLE FORMS	Bar, plate, sheet	Bar, plate, sheet, strip	Bar	Bar, plate, sheet, strip
USES	Lining for oil stills; weldments where 12% Cr gives sufficient corrosion resistance	General purpose grade; substitute for type 302; automobile and other trim, kitchen equipment, chemical equipment (430F is free-machining grade)		High temperature service up to 2150 F. Furnace parts, glass molds, pyrometer tubes, chemical processing equipment

[a] Maximum values unless otherwise stated. [b] Brinell. [c] Minimum.

Martensitic Stainless Steels—Wrought

AISI Type ➜	403, 410	414	416	420	431
COMPOSITION, %	C 0.15 max, Cr 11.5–13.5	C 0.15 max, Cr 11.5–13.0, Ni 1.25–2.5	C 0.15 max, Cr 12–14, P, S or Se 0.07 min, Mo or Zr 0.06 max	C > 0.15, Cr 12–14	C 0.20 max, Cr 15–17, Ni 1.25–2.50
PHYSICAL PROPERTIES					
Density, lb/cu in	0.28	0.28	0.28	0.28	0.28
Melting Point, F	2700–2790	—	2700–2790	2650–2750	2650
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	14.4	14.4	14.4	14.4	11.7
Coef of Ther Exp, per °F					
32-212 F	5.5×10^{-6}	5.8×10^{-6}	5.5×10^{-6}	5.7×10^{-6}	6.5×10^{-6}
32-1200 F	6.5×10^{-6}	—	6.5×10^{-6}	6.8×10^{-6}	—
Spec Ht (32–212 F), Btu/lb/°F	0.11	0.11	0.11	0.11	0.11
Elec Res (rm temp), microhm-cm	57	70	57	55	72
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6
Ten Str, 1000 psi					
Annealed	65–75	115–120	75	95	125
Hard. & Temp	90–190	120–200	90–190	230	125–205
Yld Str, 1000 psi					
Annealed	35–50	90–105	40	50	95
Hard. & Temp	60–145	105–150	60–145	195	90–155
Elong (in 2 in.), %					
Annealed	25–35	15–20	30	25	20
Hard. & Temp	15–30	15–20	12–25	8	15–20
Hardness (Brinell)					
Annealed	155	235	155	195	260
Hard. & Temp	180–390	250–410	180–390	500	260–415
Impact Str (Izod), ft-lb					
Annealed	90	50	70	—	—
Hard. & Temp	35–75	45–50	20–60	10	30–50
Endurance Limit (annealed), 1000 psi	40	45	40	40	45
Creep Str (1% ext in 10,000 hr, annealed), psi					
1000 F	9200	—	9200	—	—
1300 F	1000	—	1000	—	—
THERMAL TREATMENT					
Annealing Temp, F	1500–1650	—	1500–1650	1550–1650	—
Hardening Temp, F	1700–1850	1800–1900	1700–1850	1800–1900	1800–1950
Tempering Temp, F	400–1400	400–1300	400–1400	300–700	400–1200
FABRICATING PROPERTIES					
Machinability	Fair	Poor	Good; 80% of screw stock	Fair	Poor
Weldability	Fair; small welds can be annealed	Poor	Poor	Fair	Poor
Forging Temp (start), F	2000–2200	2100–2200	2100–2300	2000–2200	2100–2250
CORROSION RESISTANCE	Good resistance to weather and water; also good resistance to some chemicals				
AVAILABLE FORMS	Plate, sheet, strip, bar, tube, rounds, structural and bar shapes, round and flat wire, tubing				
USES	Steam turbine blades, highly stressed parts	Springs, knife blades, tempered rules	Automatic screw machine parts	Cutlery, surgical instruments, ball bearings, magnets	High strength parts

Martensitic Stainless Steels—Wrought

AISI Type ➜	440A	440B	440C	501	502
COMPOSITION, %	C 0.60–0.75, Cr 16–18, Mo 0.75 max	C 0.75–0.95, Cr 16–18, Mo 0.75 max	C 0.95–1.20, Cr 16–18, Mo 0.75 max	C > 0.10, Cr 4–6	C 0.10 max, Cr 4-6
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.28	0.28	0.28	0.28	0.28
Melting Point, F	2500–2750	2500–2750	2500–2750	2700–2800	2700–2800
Ther Cond (212 F), Btu/hr/sq ft/°F/ft.	14.0	14.0	14.0	21.2	21.2
Coef of Ther Exp, per °F					
32–212 F	5.6×10^{-6}	5.6×10^{-6}	5.6×10^{-6}	6.2×10^{-6}	6.2×10^{-6}
32–1200 F	—	—	—	7.3×10^{-6}	7.3×10^{-6}
Spec Ht (32–212 F), Btu/lb/°F	0.11	0.11	0.11	0.11	0.11
Elec Res (rm temp), microhm-cm	60	60	60	40	40
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6
Ten Str, 1000 psi					
Annealed	105	107	110	70	65–70
Hard. & Temp	260	280	285	115–175	—
Yld Str, 1000 psi					
Annealed	60	62	65	30	25–30
Hard. & Temp	240	270	275	90–135	—
Elong (in 2 in.), %					
Annealed	20	18	14	28	30
Hard. & Temp	5	3	2	15–20	—
Hardness (Brinell)					
Annealed	215	220	230	160	150
Hard. & Temp	510	555	580	240–370	—
Impact Str (Izod), ft-lb					
Annealed	2	2	2	—	85
Hard. & Temp	4	3	2	—	—
Endurance Limit (annealed), 1000 psi	40	40	40	35	35
Creep Str (1% ext in 10,000 hr, annealed), psi					
1000 F	Not used in fatigue applications			9500	9500
1300 F				800	800
THERMAL TREATMENT					
Annealing Temp, F	1550–1650	1550–1650	1550–1650	1525–1600	1525–1600
Hardening Temp, F	1850–1950	1850–1950	1850–1950	1600–1700	—[a]
Tempering Temp, F	300–800	300–800	300–800	400–1400	—[a]
FABRICATING PROPERTIES					
Machinability	Fair	Fair	Fair	—	—
Weldability	Welding not generally recommended	Welding not generally recommended	Welding not recommended	—	—
Forging Temp (start), F	1900–2200	1900–2150	1900–2100	—	—
CORROSION RESISTANCE	Good resistance to weather and water; also good resistance to some chemicals				
AVAILABLE FORMS	Plate, sheet, strip, bar, tube, rounds, structural and bar shapes, round and flat wire, tubing				
USES	Instruments, cutlery, valves			Applications requiring heat resistance and good mechanical properties at elevated temperatures	

[a] Generally used in annealed condition only.

Age Hardenable Stainless Steels—Wrought

Type ➡	Stainless W	17-4PH	Cast 17-4PH	17-7PH	AM3 0
COMPOSITION, %	C 0.07, Cr 17, Ni 7, Ti 0.70, Al 0.20	C 0.04, Cr 16.5, Ni 4, Cu 4, Cb & Ta 0.35	C 0.07, max, Cr 15.75–16.75, Ni 3.50–4.25, Cu 3.50–4.25, N 0.045 max	C 0.07, Cr 17, Ni 7, Al 1.10	C 0.07, Cr 17, Ni 4, Mo 2.75
PHYSICAL PROPERTIES[a]					
Density, lb/cu in.	0.280	0.281	0.280	0.276	0.290
Ther Cond (212–300 F), Btu/hr/sq ft/°F/ft	10.0	10.4	10.4	9.7	—
Coef of Ther Exp (70–200 F), per °F	5.5×10^{-6}[b]	6.0×10^{-6}	6.0×10^{-6}	6.2×10^{-6}	9.0×10^{-6}[c]
Elec Res (68 F), microhm-cm	100	98	98	86.5	70.97
Magnetic Perm (max)	101	151	95	111	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	28.3×10^{6}	28.5×10^{6}	28.5×10^{6}	29.5×10^{6}	28.0×10^{6}
Ten Str, 1000 psi					
Sol'n Treated	135	150	152	130	186
Aged[d]	210[e], 190[f]	195[g], 161[h]	170[i], 130[j]	215[k], 200[l]	199[m], 189[n]
Yld Str (0.2% offset), 1000 psi					
Sol'n Treated	95	110	83	40	52
Aged[d]	195[e], 170[f]	180[g], 155[h]	140[i], 100[j]	200[k], 185[l]	159[m], 163[n]
Elong (in 2 in.), %					
Sol'n Treated	7	12	5	30	22
Aged[d]	7[e], 8[f]	13[g], 15[h]	6[i], 12[j]	8[k], 9[l]	11[m], 15[n]
Hardness (Rockwell)					
Sol'n Treated	C25	C32	C41	B85	B94
Aged[d]	C43[e], C39[f]	C42[g], C35[h]	390[i,p], 310[j,p]	C45[k], C43[l]	C41[m], C41[n]
Rupture Stress (1000 hr), 1000 psi					
700 F	—	130[g]	130[g]	138[k]	—
800 F	—	89[g]	89[g]	100[k]	161[m]
900 F	—	48[g]	—	57[k]	99[m]
Creep Str (1000 hr, 700 F), 1000 psi					
0.1%	—	—	120	135[k]	—
0.01%	—	—	80	105[k]	—
THERMAL TREATMENT					
Solution Temp, F	1850–1950	1875–1925	1800–1850	1800–1850	1700–1750
Final Aging Temp, F	950–1050	900–1000	850–900	950–1050	850
FABRICATING PROPERTIES					
Hot Working Temp Range, F	1700–2300	1800–2200	—	To 2150	1800–2350
Machinability	Slightly easier to machine than type 302	Similar to type 410 (280–320 Bhn)	Similar to type 410 (280–320 Bhn)	Not often machined	Similar to type 302
Weldability	Readily weldable by arc and resistance processes applicable to stainless steels				
CORROSION RESISTANCE	Not outstanding; suitable for conditions met by cold rolled type 301. Not subject to intergranular embrittlement. AM350: superior compared to other hardenable stainless steels. Cast 17–4PH: good resistance to sea water corrosion				
AVAILABLE FORMS	Bars, forging billets, plate	Bars, forging billets, wire	Castings	All wrought forms	Bar, wire, sheet, strip, plate
USES	Used where high strength-weight ratio, corrosion resistance, and good strength at moderate temperatures are required		Chemical equipment needing strength, galling resistance	Used where high strength-weight ratio, corrosion resistance, and good strength at moderate temperatures are required	

[a] Condition is sol'n treated except 17–7PH which is precipitation hardened. [b] 32–212 F. [c] 70–1000 F.

[d] Treatment as indicated here:

1. Sol'n treated, aged at following temp and air cooled: [e] 950 F; [f] 1050 F; [g] 900 F; [h] 1100 F; [i] 875 F (min value); [j] 1050 F (min value).
2. Sol'n treated, transformed (1400 F) and air cooled, aged at following temp and air cooled: [k] 950 F; [l] 1050 F.
3. Sol'n treated, subzero cooled at −100 to −130 F, tempered 2 hr at following temp: [m] 750 F; [n] 950 F.

[p] Brinell.

Carbon Steels—Cast

Class[a] ➡	60,000	65,000	70,000	80,000	85,000	100,000
PHYSICAL PROPERTIES						
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	13–16	13–16	13–16	13–16	13–16	13–16
Magnetic?	Yes	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[b]						
Mod of Elast in Tension, psi	30.1×10^6	30.1×10^6	30×10^6	29.9×10^6	29.9×10^6	29.7×10^6
Ten Str, 1000 psi	60[c]	65[d]	70[d]	80[e]	85[e]	100[f]
Yld Point, 1000 psi	30[c]	35[d]	38[d]	45[e]	50[e]	70[f]
Elong (in 2 in.), %	32[c]	30[d]	28[d]	26[e]	24[e]	20[f]
Red. of Area, %	55[c]	53[d]	50[d]	43[e]	40[e]	46[f]
Hardness (Brinell)	120[c]	130[d]	140[d]	160[e]	175[e]	200[f]
Impact Str (Izod), ft-lb						
70 F	30[c]	30[d]	30[d]	25[e]	20[e]	30[f]
−50 F	8[c]	12[d]	10[d]	12[e]	10[e]	15[f]
Endurance Limit, 1000 psi	25[c]	28[d]	31[d]	35[e]	38[e]	47[f]
THERMAL TREATMENT						
Annealing Temp, F	About 200 F above critical range					
Quenching Temp, F	About 100 F above critical range					
FABRICATING PROPERTIES						
Machinability Index[g]	55	60	65	70	70	65
Weldability	Can be welded by procedures used for welding wrought steels of similar composition					
CORROSION RESISTANCE	When brought into contact with moisture and air, carbon steels rust at rates that are not affected by carbon content. If salts are present, corrosion rate is increased. Attacked readily by acids, but resistant to alkalis at ordinary temperatures					
USES	Applications requiring low electrical resistivity, good magnetic properties, carburizing and case hardening, weldability	Applications requiring excellent weldability; medium strength with good machinability and high ductility		Applications requiring high strength with good machinability, toughness and excellent fatigue resistance	Applications requiring wear resistance and hardness	

[a] Tensile strength, psi.
[b] Normally expected values for steel castings having tensile strength given.
[c] **Annealed.**
[d] **Normalized.**
[e] **Normalized and tempered.**
[f] Quenched and tempered.
[g] Based on AISI B1112 steel = 100.

Low Alloy Steels—Cast

Class[b] ➡	70,000	80,000	90,000	100,000	110,000
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	15–20	15–20	15–20	15–20	15–20
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[c]					
Mod of Elast in Tension, psi	29-30 x 10^6	29-30 x 10^6	29-30 x 10^6	29-30 x 10^6	29-30 x 10^6
Ten Str, 1000 psi	70[e]	80[e]	90[e]	100[e]	110[f]
Yld Point, 1000 psi	45	50	60	68	85
Elong (in 2 in.), %	26	24	22	20	20
Red. of Area, %	56	50	46	42	45
Hardness (Brinell)	150	170	190	209	235
Impact Str (Charpy), ft-lb					
70 F	35	30	26	22	23
–50 F	25	20	15	12	18
Endurance Limit, 1000 psi	33	38	41	45	49
THERMAL TREATMENT					
Annealing Temp, F	About 200 F above critical range				
Quenching Temp, F	About 100 F above critical range				
FABRICATING PROPERTIES					
Machinability Index[d]	65	70	70	65	60
Weldability	Can be welded by procedures used for wrought steels of similar composition				
CORROSION RESISTANCE	Similar to corrosion resistance of carbon steels				
USES	Applications requiring excellent weldability; medium strength with high toughness and good machinability; good high temperature properties		Applications requiring toughness or excellent high temperature and deep hardening properties		Applications requiring high resistance to impact; excellent low temperature properties; deep hardening; or excellent combination of strength and toughness

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[a] Below 8% total alloy content.
[b] Tensile strength, psi.
[c] Normally expected values for steel castings having tensile strength given.
[d] Based on AISI B1112 steel = 100.
[e] Normalized and tempered.
[f] Quenched and tempered.

Low Alloy Steels—Cast

Class[b] →	120,000	150,000	175,000	200,000
PHYSICAL PROPERTIES				
Density, lb/cu in	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70-1200 F), per °F	$8.0\text{–}8.3 \times 10^{-6}$	$8.0\text{–}8.3 \times 10^{-6}$	$8.0\text{–}8.3 \times 10^{-6}$	$8.0\text{–}8.3 \times 10^{-6}$
Spec Ht, Btu/lb/°F	0.10-0.11	0.10-0.11	0.10-0.11	0.10-0.11
Elec Res (68 F), microhm-cm	15-20	15-20	15-20	15-20
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[c]				
Mod of Elast in Tension, psi	$29\text{–}30 \times 10^{6}$	$29\text{–}30 \times 10^{6}$	$29\text{–}30 \times 10^{6}$	$29\text{–}30 \times 10^{6}$
Ten Str, 1000 psi	120[f]	150[f]	175[f]	200[f]
Yld Point, 1000 psi	95	125	148	170
Elong. (in 2 in.), %	16	12	8	5
Red. of Area, %	38	25	20	11
Hardness (Brinell)	245	300	340	400
Impact Str (Charpy), ft-lb				
70 F	20	14	10	—
–50 F	16	10	6	—
Endurance Limit, 1000 psi	55	65	77	85
THERMAL TREATMENT				
Annealing Temp, F	About 200 F above critical range			
Quenching Temp, F	About 100 F above critical range			
FABRICATING PROPERTIES				
Machinability Index[d]	50	30	—	—
Weldability	Can be welded by procedures used for wrought steels of similar composition			
CORROSION RESISTANCE	Generally similar to carbon steels			
USES	Applications requiring high resistance to impact, excellent low temperature properties, deep hardening; excellent combination of strength and toughness	Applications requiring deep hardening, high strength, wear resistance, fatigue resistance	Applications requiring high strength, wear resistance, high hardness, high fatigue resistance	

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[a] Below 8% total alloy content.
[b] Tensile strength, psi.
[c] Normally expected values for steel castings having tensile strength given.
[d] Based on AISI B1112 steel = 100.
[f] Quenched and tempered.

Stainless Steels—Cast

ACI Type ➡	CA-15	CA-40	CB-30	CC-50
COMPOSITION, %	Cr 11.5–14.0, Ni 1.0 max, C 0.15 max, Mn 1.0 max, Si 1.5 max	Cr 11.5–14.0, Ni 1.0 max, C 0.20–0.40, Mn 1.00 max, Si 1.50 max	Cr 18–22, Ni 2.0 max, C 0.30 max, Mn 1.00 max, Si 1.00 max	Cr 26–30, Ni 4.0 max, C 0.50 max, Mn 1.0 max, Si 1.0 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.275	0.275	0.272	0.272
Melting Point, F	2750	2725	2725	2725
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	14.5	14.5	12.8	12.6
Coef of Ther Exp (70–1000 F), per °F	6.4×10^{-6}	6.4×10^{-6}	6.5×10^{-6}	6.4×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.11	0.11	0.11	0.12
Elec Res (70 F), microhm-cm	78	76	76	77
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29×10^6	29×10^6	29×10^6	29×10^6
Ten Str, 1000 psi				
Annealed	—	—	95^d	97^e
As Cast	—	—	—	70–95
Hard. & Temp.	200^a, 100^b	220^a, 110^c	—	—
Yld Str (0.2% offset), 1000 psi				
Annealed	—	—	60^d	65^e
As Cast	—	—	—	60–65
Hard. & Temp	150^a, 75^b	165^a, 67^c	—	—
Elong (in 2 in.), %				
Annealed	—	—	15^d	18^e
As Cast	—	—	—	2–15
Hard. & Temp.	7^a, 30^b	1^a, 18^c	—	—
Hardness (Brinell)				
Annealed	—	—	195^d	210^e
As Cast	—	—	—	193–212
Hard. & Temp	390^a, 185^b	470^a, 212^c	—	—
Impact Str (Charpy, keyhole notch), ft-lb				
Annealed	—	—	2^d	—
As Cast	—	—	—	2–45 (Izod V notch)
Hard. & Temp	15^a, 35^b	1^a, 3^c	—	—
THERMAL TREATMENT				
Annealing Temp, F^f Hardening Temp, F^f	1450–1650 f.c. 1800–1850 a.c. or o.q.	1450–1650 f.c. 1800–1850 a.c. or o.q.	1450 f.c. and 1000 a.c. Practically nonhardenable by heat treatment	1450 f.c. or a.c. Nonhardenable by heat treatment
Tempering Temp, F	<600 or 1100–1500. Highest strength by tempering below 600		—	—
FABRICATING PROPERTIES				
Castability	Section thicknesses from $\frac{3}{16}$ in. up can be cast satisfactorily. Somewhat lighter sections can be cast in some parts. Difficult-to-run thin sections and designs involving appreciable changes in section should be avoided. Normal shrinkage for these alloys is $\frac{1}{4}$ in. per ft, except CC-50 which shrinks $\frac{7}{32}$ in. per ft			
Weldability	Can be welded by metal arc, inert-gas arc and oxyacetylene gas methods. Metal arc most frequently used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance resulting from carbon pickup. Castings should be preheated and postheated			
CORROSION RESISTANCE	Good atmospheric corrosion resistance. Excellent resistance to many organic media in relatively mild service		Resists nitric acid, alkaline solutions, many organic chemicals, oxidizing atmospheres up to 1400 F	Excellent resistance to dilute sulfuric acid in mine waters; mixed nitric and sulfuric acids, and oxidizing acids of all types
USES	Pump casing, bushings and liners, impellers, shafts, turbine blades, stuffing boxes, valve bodies and trim, furnace burner tips	Choppers, cutting blades, cylinder liners, pump parts, steam turbine parts, molds and dies	Furnace brackets and hangers, pump parts, rabble arms, tube supports, valve bodies and parts	Bushings, cylinder liners, pump casings and impellers, valve bodies and seats

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[a] Air cooled from 1800 F, tempered at 600 F.
[b] Air cooled from 1800 F, tempered at 1450 F.
[c] Air cooled from 1800 F, tempered at 1400 F.
[d] Annealed at 1450 F, furnace cooled to 1000 F, air cooled.
[e] Air cooled from 1900 F.
[f] f.c. = furnace cool, a.c. = air cool, o.q. = oil quench.

Stainless Steels—Cast

ACI Type ➡	CE-30	CF-8	CF-20	CF-8M, CF-12M	CF-8C
COMPOSITION, %	Cr 26–30, Ni 8–11, C 0.30 max, Mn 1.50 max, Si 2.00 max	Cr 18–21, Ni 8–11, C 0.08 max, Mn 1.50 max, Si 2.00 max	Cr 18–21, Ni 8–11, C 0.20 max, Mn 1.50 max, Si 2.00 max	Cr 18–21, Ni 9–12, Mo 2.0–3.0, C 0.08 (CF-8M) or 0.12 (CF-12M), Mn 1.50 max, Si 2.00 max	Cr 18–21, Ni 9–12, Cb 1.0 max[g], C 0.08 max, Mn 1.50 max, Si 2.00 max
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.277	0.280	0.280	0.280	0.280
Melting Point, F	2650	2600	2575	2550	2600
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	9.2	9.2	9.4	9.3
Coef of Ther Exp (70–1000 F), per °F	9.6×10^{-6}	10.0×10^{-6}	10.4×10^{-6}	9.7×10^{-6}	10.3×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.14	0.12	0.12	0.12	0.12
Elec Res (70 F), microhm-cm	85	76	78	82	71
Magnetic Permeability	>1.5	1.0–1.3[j]	1.01	1.50–2.50	1.20–1.80
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	25×10^6	28×10^6	28×10^6	28×10^6	28×10^6
Ten Str, 1000 psi					
As Cast	95	—	—	—	—
Water Quenched[h]	97	77	77	80	77
Yld Str (0.2% offset), 1000 psi					
As Cast	60	—	—	—	—
Water Quenched[h]	63	37	36	42	38
Elongation (in 2 in.), %					
As Cast	15	—	—	—	—
Water Quenched[h]	18	55	50	50	39
Hardness (Brinell)					
As Cast	170	—	—	—	—
Water Quenched[h]	170	140	163	156–170	149
Impact Str (Charpy keyhole notch, water quenched[h]), ft-lb	—	74	60	70	30
FABRICATING PROPERTIES					
Castability	Section thicknesses from $\frac{3}{16}$ in. up can be cast satisfactorily. Somewhat lighter sections are also possible in some parts. Good castability of these alloys permits designs involving intricate shapes, but drastic changes in section should be avoided and uniform thickness should be maintained as far as possible				
Quenching Temp, F[i]	1950–2050	1950–2050	2000–2100	1950–2100	1950–2050
Weldability	Can be welded by metal arc, inert-gas arc and oxyacetylene gas methods. Metal arc most frequently used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance caused by carbon pickup. Preheating not necessary, but castings should be quenched from the range 1950 to 2100 F to restore maximum corrosion resistance. This heat treatment is not always necessary, however with CE-30 and CF-8C alloys				
CORROSION RESISTANCE	Particularly resistant to sulfurous acid, mixtures of dilute sulfuric and sulfurous acids, sulfuric and nitric acids, and sulfites	Resists strongly oxidizing media such as boiling nitric acid, sulfuric acid and sulfates, and organic acids	Similar to CF-8 but used under less drastic conditions	Resists reducing media. More resistant to pitting corrosion than CF-8 in contact with chlorides. Not as resistant to boiling nitric acid as CF-8	Similar to CF-8
USES	Process equipment such as digester fittings, fractionating towers, piping, pump bodies and casings, valve bodies and parts	Autoclaves, blast furnaces, bushings, filter press plates, hardware, headers and heating coils, pump parts, spray nozzles, valve parts	Cylinder liners, pumps, return bends, rolls, circuit breaker parts, valve parts	Agitators, evaporator parts, jet engine components, spray nozzles, high pressure steam valves	Aircraft shroud assemblies, autoclaves, chemical tubing, fittings, jet engine parts, marine fittings

[g] Minimum is eight times carbon content.

[h] **Water quenched from 2000 F.**

[i] Water, oil or air quench.

[j] After heat treatment.

continued on next page

Stainless Steels—Cast

ACI Type ➜	CF-16F	CH-20	CK-20	CN-7M
COMPOSITION, %	Cr 18–21, Ni 9–12, C 0.16 max, Mo 1.50 max, Se 0.20–0.35, Mn 1.50 max, Si 2.00 max	Cr 22–26, Ni 12–15, C 0.20 max, Mn 1.50 max, Si 2.00 max	Cr 23–27, Ni 19–22, C 0.20 max, Mn 1.50 max, Si 2.00 max	Cr 19–22, Ni 27.5–30.5, Mo 1.75–2.50, Cu 3.00 min, C 0.07 max, Mn 1.50 max, Si 1.50 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.280	0.279	0.280	0.289
Melting Point, F	2550	2600	2600	2650
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.4	8.2	8.2	12.1
Coef of Ther Exp (70–1000 F), per °F	9.9×10^{-6}	9.6×10^{-6}	9.2×10^{-6}	9.7×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.12	0.12	0.12	0.11
Elec Res (70 F), microhm-cm	72	84	90	90
Magnetic Permeability	1.0–2.0	1.71[j]	1.02	1.01–1.10
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	28×10^{6}	28×10^{6}	29×10^{6}	24×10^{6}
Ten Str, 1000 psi[h]	77	88	76	69
Yld Str (0.2% offset), 1000 psi[h]	40	50	38	31
Elong (in 2 in.), %[h]	52	38	37	48
Hardness (Brinell)[h]	150	190	144	130
Impact Str (Charpy, keyhole notch), ft-lb[h]	75	30	46 (Izod V notch)	70
FABRICATING PROPERTIES				
Castability	Section thicknesses from $\frac{3}{16}$ in. up can be cast satisfactorily. Somewhat lighter sections are also possible on some parts. Good castability permits designs involving intricate shapes, but drastic changes in section should be avoided			
Quenching Temp, F[i]	2000–2100	2000–2100	2000–2150	1950–2050
Weldability	Can be welded by metal arc, inert-gas arc, and oxyacetylene gas methods. Metal arc welding most used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance resulting from carbon pickup			
	Preheating not necessary, but castings should be quenched from 2000–2100 F to restore maximum corrosion resistance			Preheating at 400 F necessary. After welding, castings should be quenched from 2000 F
CORROSION RESISTANCE	Similar to but somewhat inferior to CF-8	Resistant to hot dilute sulfuric acid. Superior to CF-8 in certain media	Similar to CH-20, but better resistance at elevated temperatures	Resists sulfuric acid and many reducing chemicals. Good resistance to dilute hydrochloric acid and salt solutions
USES	Bearings, bushings, fittings, pump and machinery parts	Digester fittings, roasting equipment, valves, pump parts	Digesters, filter press parts, fittings, jet engine parts, pumps, valves	Filter parts; heat exchanger parts; pickling rolls, hooks, racks and tanks; valve parts

[h] Water quenched from 2000 F.
[i] Water, oil or air quench.
[j] After heat treatment.

Heat Resistant Alloys—Cast

ACI Type ➡	HA	HC	HD	HE	HF
COMPOSITION, %	C 0.20 max, Mn 0.35-0.65, Si 1.00 max, P 0.04 max, S 0.04 max, Mo 0.90- 1.20, Cr 8-10	C 0.50 max, Mn 1.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 26-30, Ni 4 max	C 0.50 max, Mn 1.50 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 26-30, Ni 4-7	C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max. Cr 26-30, Ni 8-11	C 0.20-0.40, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 19-23. Ni 9-12
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.279	0.272	0.274	0.277	0.280
Melting Point, F	2750	2725	2700	2650	2550
Ther Cond (212 F), Btu/hr/sq ft/ft/°F	15.2	12.6	12.6	10.0^{b}	9.0
Coef of Ther Exp (70–1200 F), per °F	7.5 x 10^{-6}	6.4 x 10^{-6}	8.0 x 10^{-6}	9.9 x 10^{-6}	10.1 x 10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.11	0.12	0.12	0.14	0.12
Elec Res (70 F), microhm-cm	70	77	81	85	80
Magnetic Permeability	Ferromagnetic	Ferromagnetic	Ferromagnetic	1.3-2.5	1.0
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29 x 10^{6}	29 x 10^{6}	27 x 10^{6}	25 x 10^{6}	28 x 10^{6}
Ten Str, 1000 psi^{a}	95^{d}, 107^{b}	70–110, 115^{c}	85, —	95, 90^{c}	85, 100^{c}
Yld Str (0.2% offset), 1000 psi^{a}	65^{d}, 81^{b}	65-75, 80^{c}	48, —	45, 55^{c}	45, 50^{c}
Elong (2 in.), %^{a}	23^{d}, 21^{b}	2-19, 18^{c}	16, —	20, 10^{c}	35, 25^{c}
Hardness (Brinell)^{a}	180^{d}, 220^{b}	190–223, —	190, —	200, 270^{c}	165, 190^{c}
ELEVATED TEMPERATURE PROPERTIES					
Ten Str, 1000 psi	67 (1000 F), 44 (1100 F)	—	36 (1400 F), 23 (1600 F), 15 (1800 F)	—	57 (1200 F), 35 (1400 F), 22 (1600 F)
Yld Str (0.2% offset), 1000 psi	42 (1000 F), 32 (1100 F)	—	—	—	21 (1400 F)
Elong (2 in.), %	36 (1100 F)	—	14 (1400 F), 18 (1600 F), 40 (1800 F)	—	16 (1200 F), 20 (1400 F), 22 (1600 F)
Creep Str (0.0001%/hr), 1000 psi	16 (1000 F), 7.2 (1100 F), 3.1 (1200 F)	1.3 (1400 F), 0.75 (1600 F), 0.36 (1800 F)	3.5 (1400 F), 1.9 (1600 F), 0.9 (1800 F)	4.0 (1400 F), 2.4 (1600 F), 1.4 (1800 F)	13 (1200 F), 6.0 (1400 F), 3.2 (1600 F)
Rupture Str, 1000 psi 10 Hr	45 (1000 F)	4.6 (1400 F), 2.0 (1600 F), 1.1 (1800 F)	14 (1400 F)	—	37 (1200 F), 20 (1400 F), 10 (1600 F)
100 Hr	37 (1000 F)	3.3 (1400 F), 1.7 (1600 F), 0.85 (1800 F)	10 (1400 F), 5 (1600 F), 2.5 (1800 F)	11 (1400 F), 5.3 (1600 F), 2.5 (1800 F)	30 (1200 F), 14 (1400 F), 6.0 (1600 F)
1000 Hr	27 (1000 F)	2.3 (1400 F), 1.3 (1600 F), 0.62 (1800 F)	7 (1400 F)	—	17 (1200 F), 8.0 (1400 F), 3.8 (1600 F)
FABRICATING PROPERTIES					
Annealing Temp, F	1625	—	—	—	1900^{e}
Machinability	Fair	Good	Good	Good	Good
Weldability	Weldable by all common methods. Preheating, postheating desirable		Weldable by all common methods. Preheating not required		
USES	Fan blades, furnace rollers, lehr rolls, refinery fittings, trunnions	Grate bars, dampers, kiln parts, rabble blades, salt pots, tuyeres	Brazing furnace parts, cracking equipment, furnace blowers, pouring spouts, salt pots, gas burner parts	Billet skids, burner nozzles, furnace conveyors, tube supports, soot blower elements	Electrode arms, burner tips, annealing boxes, wear plates, gas burner rings, conveyor belts, dampers

[a] As cast and heat treated values given in that order. [b] Normalized at 1825 F, tempered at 1250 F.
[c] Aged 24 hr at 1400 F, furnace cooled. [d] Annealed. [e] Before cyclic temperature service. 6 hr at 1900 F may improve life. [f] At 1500 F.

continued on next page

Heat Resistant Alloys—Cast

ACI Type →	HH		HI	HK	HL
COMPOSITION, %	C 0.20-0.50, Cr 24-48, Mn 2.00 max, Ni 11-14, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, N 0.2 max		C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 26-30, Ni 14-18	C 0.20-0.60, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 24-28, Ni 18-22	C 0.20-0.60, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 28-32, Ni 18-22
PHYSICAL PROPERTIES					
Density, lb/cu in	0.279		0.279	0.280	0.279
Melting Point, F	2500		2550	2550	2600
Ther Cond (212F), Btu/hr/sq ft/ft/°F	8.2		10.9	8.2	8.2
Coef of Ther Exp (70-1800 F), per °F	10.5×10^{-6}		10.5×10^{-6}	10.0×10^{-6}	9.9×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.12		0.12	0.12	0.12
Elec Res (70 F), microhm-cm	75-85		—	90	94
Magnetic Permeability	1.0-1.9		1.0-1.7	1.02	1.01
	Type I[h]	Type II[i]			
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	27×10^6	27×10^6	27×10^6	29×10^6	29×10^6
Ten Str, 1000 psi[g]	80, 86	85, 92	80, 90	75, 85	82, —
Yld Str, 1000 psi[g]	50, 55	40, 45	45, 65	50, 50	52, —
Elong (2 in.), %[g]	25, 11	15, 8	12, 6	17, 10	19, —
Hardness (Brinell)[g]	185, 200	180, 200	180, 200	170, 190	192, —
ELEVATED TEMPERATURE PROPERTIES					
Ten Str, 1000 psi					
1400 F	33	35	38	—	50
1600	18.5	22	26	23	30
1800 F	9.0	11	—	—	19
Yld Str (0.2% offset), 1000 psi					
1400 F	17	18	—	—	—
1600 F	13.5	14	—	—	—
1800 F	6.3	7.0	—	—	—
Elong (2 in.), %					
1400 F	18	12	6	—	—
1600 F	30	16	12	21	—
1800 F	45	30	—	—	—
Creep Str (0.0001% hr), 1000 psi					
1400 F	3.0	7.0	6.6	6.8	7.0
1600 F	1.7	4.0	3.6	4.2	4.3
2001 F	0.3	0.8	0.8	1.0	—
2150 F	—	—	0.15	0.2	—
Rupture Str, 1000 psi					
10 Hr 1400 F	—	20	—	23	—
10 Hr 1600 F	—	10	—	11	—
10 Hr 1800 F	4.7	6.0	—	6.5	—
100 Hr 1400 F	14	14	13	14.5	15
100 Hr 1600 F	6.4	7.5	7.5	7.8	9.2
100 Hr 2000 F	1.5	1.8	1.9	2.5	—
1000 Hr 1400 F	6.5	10	8.5	9.0	—
1000 Hr 1600 F	3.8	4.7	4.8	5.0	—
1000 Hr 2000 F	—	1.2	1.2	—	—
FABRICATING PROPERTIES					
Annealing Temp, F	1900[d]	1900[d]	—	—	—
Machinability	Fair	Fair	Fair	Good	Good
Weldability	Weldable by all common methods; no preheat or postheat required				
USES	Annealing trays, tube supports, carburizing boxes, exhaust manifolds, radiant tubes, retorts, stoker parts		Billet skids, brazing fixtures, furnace rails, lead pots, tube spacers, retorts	Heat treating fixtures, rabble arms, retorts, brazing fixtures, skid rails	Carrier fingers, enameling furnace fixtures, furnace skids, stack dampers

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[d] Before cyclic temperature service. 6 hr at 1900 F may improve life.

[g] As cast and heat treated (aged 24 hr at 1400 F, furnace cooled) values given in that order. [h] Partially ferritic. [i] Austenitic.

Heat Resistant Alloys—Cast

ACI Type ➡	HN	HT	HU	HW	HX
COMPOSITION, %	C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 19-23, Ni 23-27	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 13-17, Ni 33-37	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 17-21, Ni 37-41	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 10-14, Ni 58-62	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 15-19, Ni 64-68
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.286	0.290	0.294	0.294
Melting Point, F	2500	2450	2450	2350	2350
Ther Cond (212F), Btu/hr/sq ft/ft/°F	—	7.7	—	7.7	—
Coef of Ther Exp (70-1800 F), per °F	—	9.8×10^{-6}	9.6×10^{-6}	8.8×10^{-6}	9.2×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.11	0.11	0.11	0.11	0.11
Elec Res (70 F), microhm-cm	—	100	105	112	—
Magnetic Permeability	1.10	1.10-2.00	1.10-2.00	16.0	2.0
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	27×10^6	27×10^6	27×10^6	25×10^6	25×10^6
Ten Str, 1000 psi[a]	68, —	70, 75[j]	70, 73[k]	68, 84[l]	65, 73[k]
Yld Str, 1000 psi[a]	38, —	40, 45[j]	40, 43[k]	36, 52[l]	36, 44[k]
Elong (2 in.), %[a]	17, —	10, 5[j]	9, 5[k]	4, 4[l]	9, 9[k]
Hardness (Brinell)[a]	160, —	180, 200[j]	170, 190[k]	185, 205[l]	176, 185[k]
ELEVATED TEMPERATURE PROPERTIES					
Ten Str, 1000 psi					
1400 F	—	35	40	32	—
1600 F	—	18.8	19.6	19	20.5
1800 F	—	11	10.0	10	10.7
Yld Str (0.2% offset), 1000 psi					
1400 F	—	26	—	23	—
1600 F	—	15	—	15	17.5
1800 F	—	8.0	6.2	8.0	6.9
Elong (2 in.), %					
1400 F	—	10	—	—	—
1600 F	—	26	20	—	48
1800 F	—	28	28	40	40
Creep Str (0.0001%/hr), 1000 psi					
1400 F	—	8.0	8.5	6.0	6.4
1600 F	6.3	4.5	5.0	3.0	3.2
2000 F	0.9	0.5	0.6	—	0.6
2150 F	—	0.15	—	—	—
Rupture Str, 1000 psi					
10 Hr 1400 F	—	—	—	16	18
10 Hr 1600 F	—	11	—	8.2	10
10 Hr 2000 F	—	—	—	—	2.5
100 Hr 1400 F	—	18	15	10	13
100 Hr 1600 F	9.5	8.5	8.0	6.0	6.7
100 Hr 2000 F	2.5	2.5	—	—	1.7
1000 Hr 1400 F	—	12.5	—	7.8	—
1000 Hr 1600 F	6.5	7.0	6.0	4.5	4.0
1000 Hr 2000 F	0.9	1.8	—	—	0.9
FABRICATING PROPERTIES					
Annealing Temp, F	—	1900[d]	1900[d]	—	—
Machinability	Good	Good	Good	Good	Good
Weldability	Weldable by all common methods; no preheat or postheat required				
USES	Brazing fixtures, chain, nozzles, furnace parts, radiant tubes, tube supports	Air ducts, carburizing boxes, cyanide pots, glass molds, lead pots	Articulated trays, burner tubes, lead pots, cyanide pots, muffles	Cyanide pots, gas retorts, electric heating elements, hearth plates	Autoclaves, calciner tubes, furnace parts, salt bath electrodes, muffles

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[a] As cast and heat treated values given in that order.

[d] Before cyclic temperature service. 6 hr at 1900 F may improve life.

[j] **Aged 24 hr at 1400 F, air cooled.** [k] Aged at 1400 F, furnace cooled [l] **Aged 48 hr at 1800 F, furnace cooled.**

(Advertisement)

Properties of ASTM PRESSURE VESSEL STEELS

	HIGH TEMPERATURE STEELS							
ASTM DESIGNATION	**A-204 Mo**			**A-387 (Supersedes A-301) Cr-Mo**				
	Grade A	**Grade B**	**Grade C**	**Grade A**	**Grade B**	**Grade C**	**Grade D**	**Grade E**
COMPOSITION, % based on 1" gage Firebox quality. (Values are max. unless otherwise indicated.)	C .18, Mn .90, P .035, S .04, Si .13-.32, Mo .41-.64	C .20, Mn .90, P .035, S .04, Si .13-.32, Mo .41-.64	C .23, Mn .90, P .035, S .04, Si .13-.32, Mo .41-.64	C .21, Mn .36-.84, P .035, S .040, Si .13-.32, Cr .46-.79, Mo .40-.70	C .17, Mn .36-.69, P .035, S .040, Si .13-.32, Cr .75-1.31, Mo .40-.70	C .17, Mn .36-.69, P .035, S .040, Si .48-1.02, Cr .94-1.56, Mo .40-.70	C .15, Mn .27-.63, P .035, S .040, Si .50, Cr 1.88-2.62, Mo .85-1.15	C .15, Mn .27-.63, P .035, S .040, Si .50, Cr 2.63-3.37, Mo .85-1.15
PHYSICAL PROPERTIES (c) Density, lb./cu. in. Magnetic Prop.	0.283 Magnetic. Some residual magnetism remains.			0.283 Magnetic. Some residual magnetism remains.				
PROCESS	Open Hearth or Electric Furnace			Open Hearth or Electric Furnace			Electric Furnace only	
MECHANICAL PROPERTIES	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. Annealed	Fbx. Annealed	Fbx. Annealed	Fbx. Annealed	Fbx. Annealed
Mod. of Elast. in Tension, psi	29-30x10^6	29-30x10^6	29-30x10^6	29-30x10^6	29-30x10^6	29-30x10^6	29-30x10^6	29-30x10^6
Tensile Strength, 1000 psi	65-77	70-85	75-90	65-82	60-82	60-85	60-85	60-85
Yield Point, 1000 psi min.	37	40	43	40	35	35	30(b)	30(b)
Elong. (in 2 inches), %	25	23	22	24	24	24	20	20
Red. of Area, % min.							50	50
Typical Hardness, Brinell(c)	140-165	150-180	165-200	140-175	135-175	135-180	135-180	135-180
Impact Str., Charpy Keyhole								
THERMAL TREATMENT	Over 2" gage requires grain refinement by normalizing. Under 2" may be as-rolled or stress-relieved, normalized, or normalized and stress-relieved.			All gages require grain refinement by either annealing, or normalizing and tempering. No quenching in liquid medium permitted.			All gages require annealing or normalizing and tempering.	
FABRICATING PROPERTIES(c) Formability Weldability	May be hot or cold formed. May be manual or machine welded. For all gages preheat and elevated interpass temperature are desirable. Stress relief desirable. Peening may be necessary for gages over 1 inch.			May be hot or cold formed. May be manual or machine welded. For gages under 4" preheat and elevated interpass temperature are desirable. Stress relief desirable. Peening may be necessary for gages over 1" thick.				
AVAILABLE FORMS	Plate form only. Flange quality to max. gage of 2" incl. Grades A and B, Fbx. quality to max. gage of 6" incl. Grade C, Fbx. quality to max. gage of 4" incl.			Plate form only. For Grades A, B and C Flange quality to max. gage of 2" incl., for Fbx. quality to max. gage of 6" incl. For Grades D and E to max. gage of 6" incl.				
USES	Boilers, other pressure vessels for service up to 1000°F inclusive.			Boilers, other pressure vessels. Grade A for service up to 1000°F, Grades B, C, D, & E for service up to 1200°F inclusive.				

ABBREVIATIONS: S.R., stress relieve; Fbx., firebox quality; Flg., Flange Quality

(a) Charpy Keyhole values are those required when specification made to ASTM A-300 specification.

(b) Values for these materials are yield strength (1000 psi, min.).

(c) Data or properties are not part of ASTM specifications.

Properties of LUKENS "T-1" CONSTRUCTIONAL ALLOY STEEL

(trademark)

"T-1" CONSTRUCTIONAL ALLOY STEEL

QUALITY	Composition, %	Mod. of Elast. in Tension, 1000 psi.	Tensile Strength 1000 psi (1" gage)	Yield Strength 1000 psi (1" gage)	Elong. in 2" Min. % (1" gage)	Reduction of Area, % (1" gage)	Typical Hardness Brinell	Impact Str. Charpy Keyhole	Thermal Treatment
REGULAR	C .10-.20, Mn .60-1.00, P .04, S .05, Si .15-.35, Ni .70-1.00, Cr .40-.80, Mo .40-.60, V .03-.10, Cu .15-.50, B .002-.006	30x10^6	115-135	100 min.	18	50	250-280	—	Water quench and temper
321 MIN. BHN	same	same	—	—	—	—	321 min.	—	same
FLANGE	same	same	115-135	100 min.	18	50	250-280	—	same
FIREBOX	same*	same	115-135	100 min.	18	50	250-280	15 ft. lbs. at −50°F(a)	same
FIREBOX TO ASTM CASE 1204-3	same*	same	105-135	90 min.	17	—	250-280	15 ft. lbs. at −50°F(a)	same

*For Firebox quality, check analysis limit of P 0.035 max. and S 0.04 max. applies.

(Advertisement)

LOW TEMPERATURE STEELS							HIGH STRENGTH STEELS					
A-203 Ni					**A-353 Low C, High Ni**	**A-410-57T Cr-Cu-Ni-Al**	**A-202 Cr-Mn-Si**		**A-225 Mn-V**		**A-302 Mg-Mo**	
Grade A	**Grade B**	**Grade C**	**Grade D**	**Grade E**	—	—	**Grade A**	**Grade B**	**Grade A**	**Grade B**	**Grade A**	**Grade B**
C .17, Mn .80, P .035, S .04, Si .13-.32, Ni 2.13-2.67	C .20, Mn .80, P .035, S .04, Si .13-.32, Ni 2.13-2.67	C .25, Mn .80, P .035, S .04, Si .13-.32, Ni 2.13-2.67	C .17, Mn .80, P .035, S .04, Si .13-.32, Ni 3.18-3.82	C .20, Mn .80, P .035, S .04, Si .13-.32, Ni 3.18-3.82	C .13, Mn .80, P .035, S .040, Si .13-.32, Ni 8.40-9.60	C .12, Mn .55-1.00, P .040, S .040, Cu .40-.75, Si .08-.37, Ni .47-.98, Cr .44-1.01, Al .04-.30	C .17, Mn1.00-1.45, P .035, S .04, Si .54-.96, Cr .31-.64	C .25, Mn1.00-1.45, P .035, S .04, Si .54-.96, Cr .31-.64	C .18, Mn 1.45, P .035, S .04, Si .13-.32, V .07-.16	C .20, Mn 1.45, P .035, S .04, Si .13-.32, V .07-.16	C .20, Mn .90-1.35, P .035, S .040, Si .13-.32, Mo .41-.64	C .20, Mn1.10-1.55, P .035, S .040, Si .13-.32, Mo .41-.64
0.283					0.286	0.283	0.283		0.283		0.283	
Magnetic. Some residual magnetism remains.					Magnetic. High residual magnetism remains.	Magnetic. Some residual magnetism remains.	Magnetic. Some residual magnetism remains.		Magnetic. Some residual magnetism remains.		Magnetic. High residual magnetism remains.	
Open hearth or electric furnace					Open hearth or electric furnace	Open hearth or electric furnace	Open hearth or electric furnace		Open hearth or electric furnace		Open hearth or electric furnace	
Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. Double Normalized	Fbx. Normalized	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled
29-30x10^6	29-30x10^6	29-30x10^6	29-30x10^6	29-30x10^6								
65-77	70-85	75-90	65-77	70-85	90 min.	60 min.	75-90	85-100	70-85	75-90	75-95	80-100
37	40	43	37	40	60 (b)	30	45	47	40	43	45	50
25	23	22	25	23	22	24	21	20	23	22	21	20
140-165	150-180	165-200	140-165	150-180	200	135	165-200	180-210	150-180	165-200	165-205	170-210
15 ft. lbs. at −75° F (a)			15 ft. lbs. at −150° F (a)		15 ft. lbs. at −320° F (a)	15 ft. lbs. at −150° F (a)						
Over 2″ gage requires grain refinement by normalizing. Under 2″ may be as-rolled or stress-relieved, normalized, or normalized and stress-relieved.					All gages require double normalizing.	All gages require grain refinement by normalizing.			Over 2″ gage requires grain refinement by normalizing. Under 2″ gage may be as-rolled, stress-relieved, normalized, or normalized and stress-relieved.		Over 2″ gage requires grain refinement by normalizing. Under 2″ gage may be as-rolled, stress-relieved, normalized, or normalized and stress-relieved.	
May be hot or cold formed.					May be hot or cold formed.	May be hot or cold formed.	May be hot or cold formed.		May be hot or cold formed.		May be hot or cold formed.	
Can be manual welded.					Can be manual welded.	Can be manual welded.	May be manual or machine welded.		May be manual or machine welded.		May be manual or machine welded.	
For gages under 4″ preheat and elevated interpass temperature are desirable. Stress relief desirable. Peening may be necessary.					Austenitic electrodes are desirable. No preheat required. Stress relief desirable.	For gages over 2″ thick, preheat and elevated interpass temp. are desirable. S.R. desirable.	For all gages preheat and elevated interpass temp. are desirable. Stress relief desirable. Peening may be necessary.		For gages over ½″ preheat and elevated interpass temp. are desirable. Stress relief desirable. Peening may be necessary.		For over .15 carbon preheat and elevated interpass temp. are desirable. S.R. desirable. Peening may be necessary.	
Plate form only. Flange quality to max. gage of 2″ incl. Grades A and B, Fbx. quality to max. gage of 6″ incl. Grades C, D and E, Fbx. quality to max. gage of 4″ incl.					Plate form only. Fbx. quality only to max. gage of 2″ incl.	Plate form only. Fbx. quality only.	Plate form only. Fbx. quality only to max. gage of 2″ incl.		Plate form only. Flg. quality to max. gage of 2″ incl. Grades A and B, Fbx. quality to max. gage of 4″ incl.		Plate form only. Flg. quality to max. gage of 2″ incl. Fbx. quality to max. gage of 4″ incl.	
Boilers, other pressure vessels, low temp. applications or elevated temp. up to 1000° F incl.					Primarily for pressure vessels used in low temperature applications.	Primarily for pressure vessels used in low temperature applications.	Boilers, other pressure vessels for service up to 1000° F inclusive.		Boilers, other pressure vessels for service up to 1000° F inclusive.		Boilers, other pressure vessels for service up to 1000° F inclusive.	

Formability	Weldability	Corrosion Resistance	Available Forms	Uses
Cold forming advised. Power requirements 3 to 4 times carbon steel. Springback greater than carbon steel. For bending use liberal radius.	May be manual or machine welded. Moderate preheat and interpass temp. beneficial for restrained joints and heavy gages.	Atmospheric corrosion resistance approx. 4 times that of carbon steel.	Plates up to 10″ gage inclusive.	Heavily loaded (static or dynamic) structural applications.
			Plates up to 6″ gage inclusive.	Impact abrasion resistance application.
			Plates up to 2″ gage inclusive.	Heavily loaded (static or dynamic) structural applications.
			Plates up to 6″ gage inclusive.	same as above
			Plates ¼″ gage up to 2″ gage inclusive.	ASME Code pressure vessels for temp. from −50°F through 650°F.

This data developed and compiled by Lukens Steel Company, producers of alloy and clad steel plate and heads in the widest range of sizes available anywhere. Depending on gage plates are available in widths up to 195″ and lengths up to 720″.

For copies of this chart, enlarged to 24″x18″, or for further information on the steels described, write to Manager, Marketing Service, D99 Lukens Building, Coatesville, Pennsylvania.

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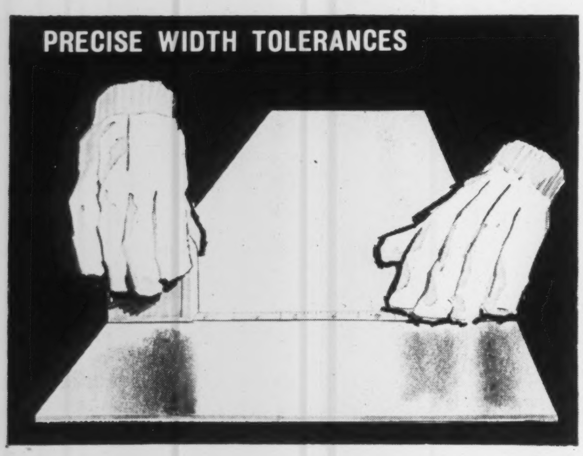

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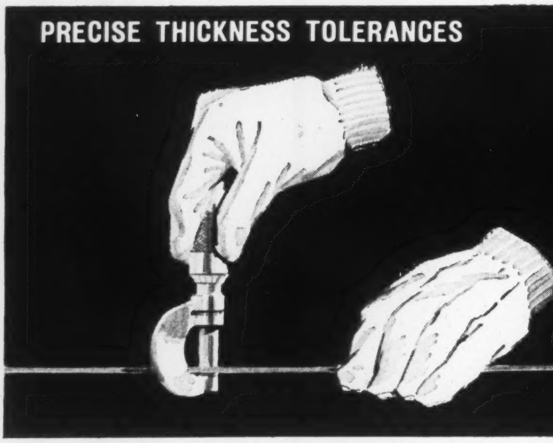

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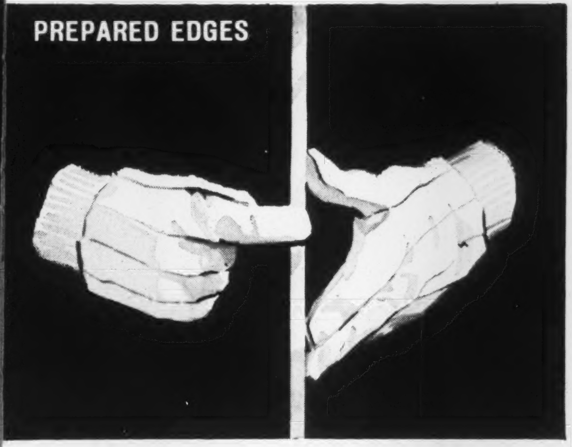

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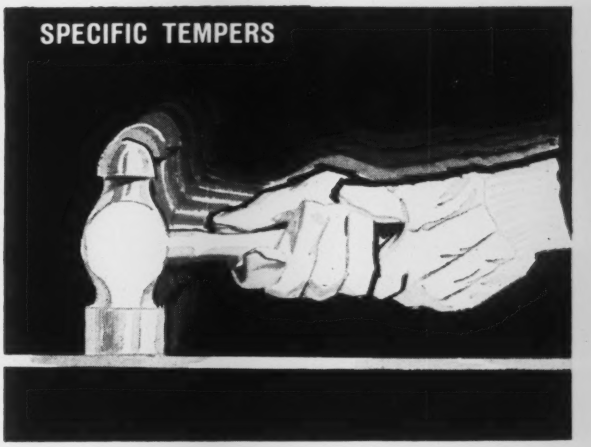

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HEAT NUMBER	ULTIMATE TENSILE STRENGTH psi	0.2% YIELD STRENGTH psi	PER CENT ELONGATION in 1″	PER CENT REDUCTION of AREA
℞ 36-57	194,400	168,000	13.5	40.8
℞ 36-58	202,400	170,400	12.5	28.0
℞ 36-59	192,800	160,400	12.0	39.0
℞ 36-60	198,000	162,400	13.5	40.0

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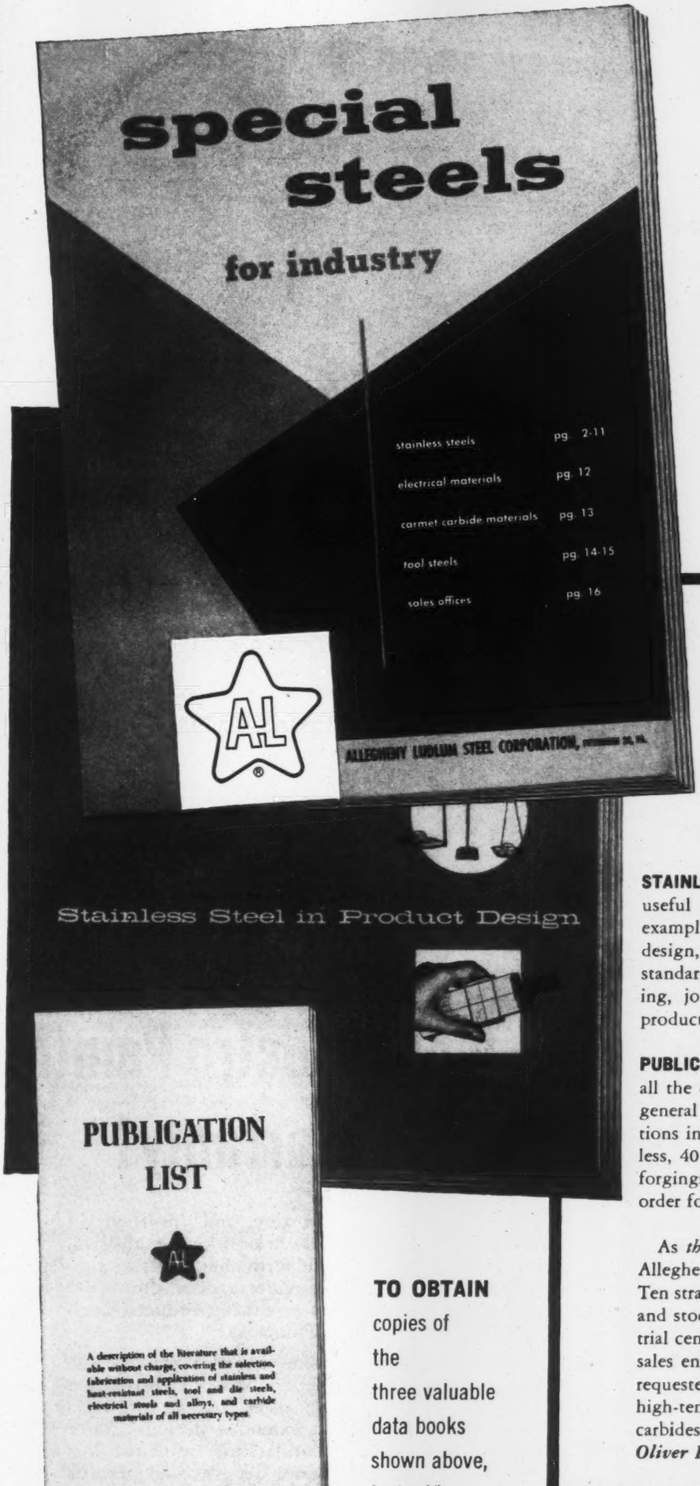
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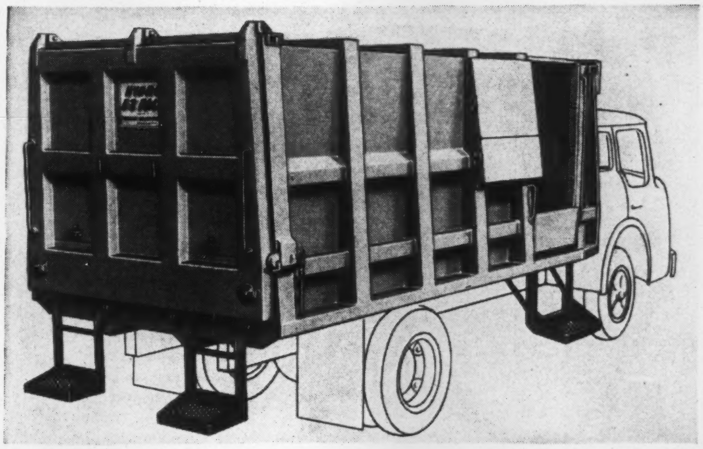
Electro Paintlok Sheets are strong and rigid—only steel itself provides the *strength* of steel. A pure, uniform coating of zinc, applied by electro-galvanizing, provides extra resistance to corrosion, even if the surface of a Berry Door should be scratched or abraded.

After the zinc is applied, Republic Electro Paintlok Sheets are treated chemically, giving them an inert, finely crystalline, non-metallic phosphate coating which is integral with the zinc, and absorbent in character. When a good grade of paint is applied, this coating grips the paint with thousands of tiny teeth that never let go—provides greater durability and beauty for steel doors or other products fabricated of Republic Electro Paintlok.

In addition to these customer benefits (which make products more salable), Electro Paintlok provides a number of important advantages for the manufacturer. It may be stored for extended periods, under approved warehousing conditions, without loss caused by rusting. It increases die life, and permits faster fabrication, with correspondingly lower production costs.

For additional details on Republic Electro Paintlok Steel Sheets, and the advantages they can bring to your particular application, contact your Republic representative now. Or mail the convenient coupon at far right.



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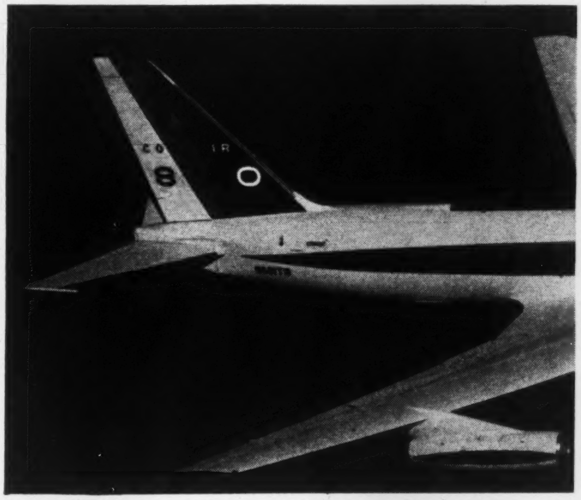
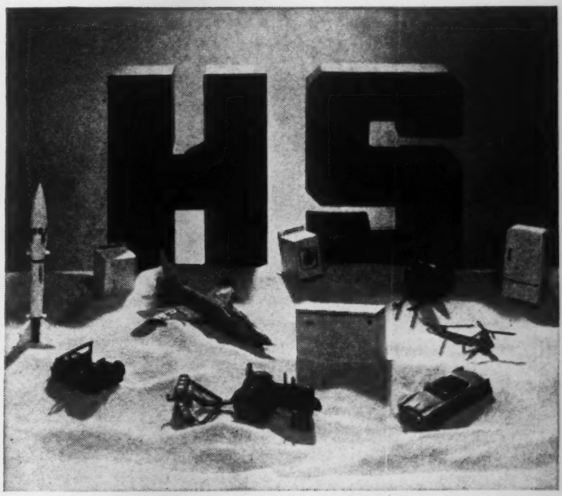


REPUBLIC STAINLESS STEEL INCREASES HEAT- AND CORROSION-RESISTANCE in the leading edges of the Convair 880's vertical fin and horizontal stabilizer where anti-icing is accomplished through electrical heating of the metal. Republic ENDURO® Stainless Steel increases strength while permitting use of thinner, lighter gages. It is readily formed into desired shapes by cold forming, drawing, and bending operations. Republic Stainless Steel is supplied in all commercial forms. Send coupon for facts.



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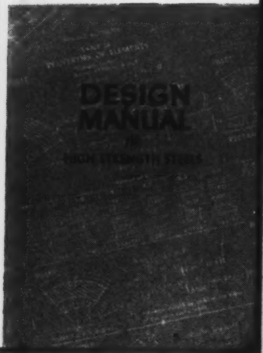
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USS stainless steel
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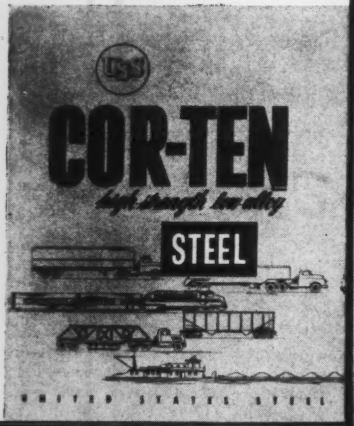
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high strength low alloy
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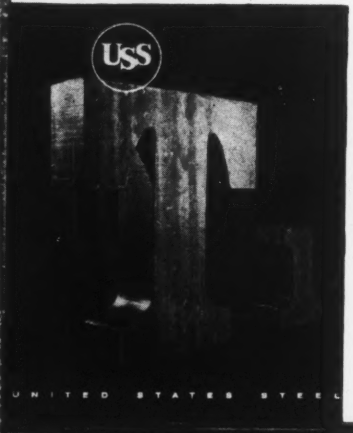
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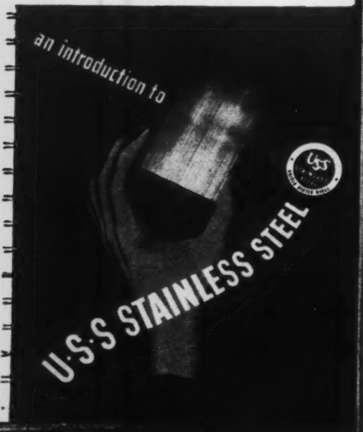
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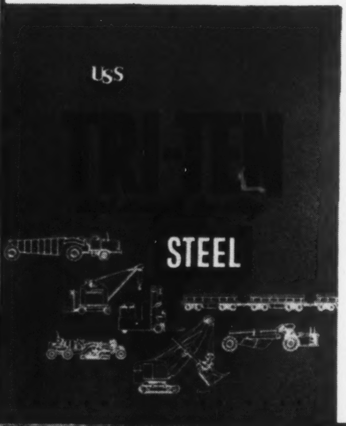
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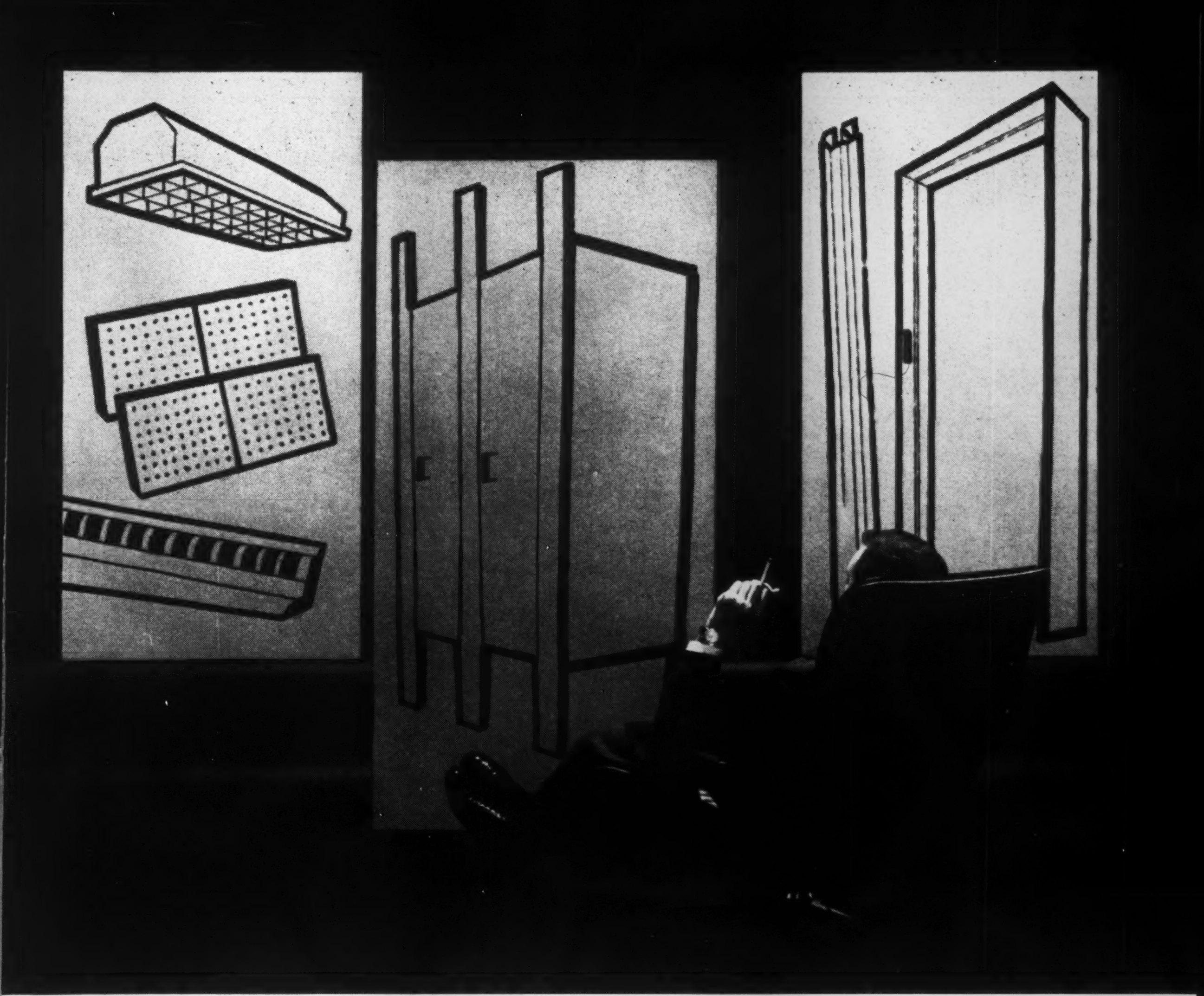

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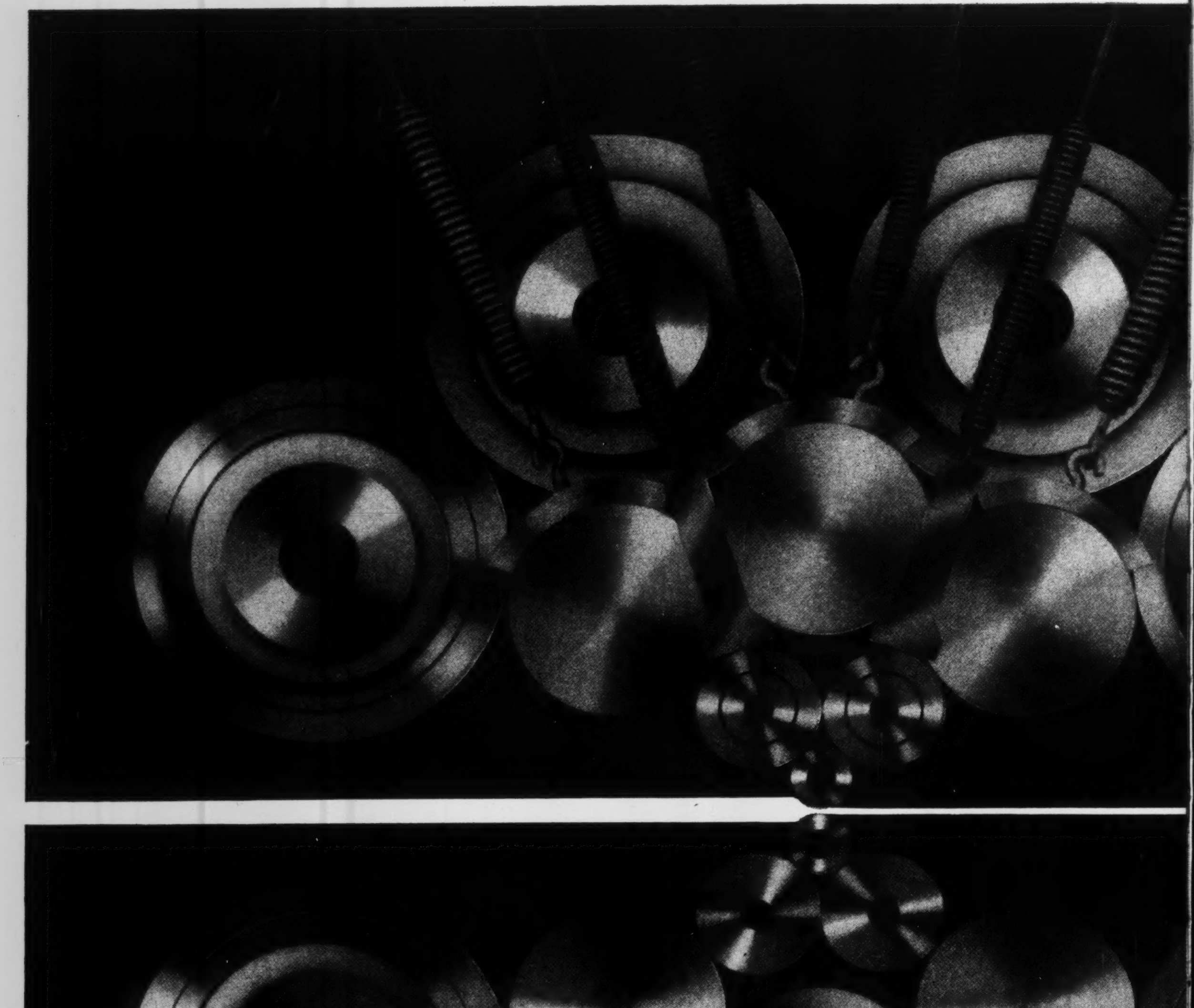

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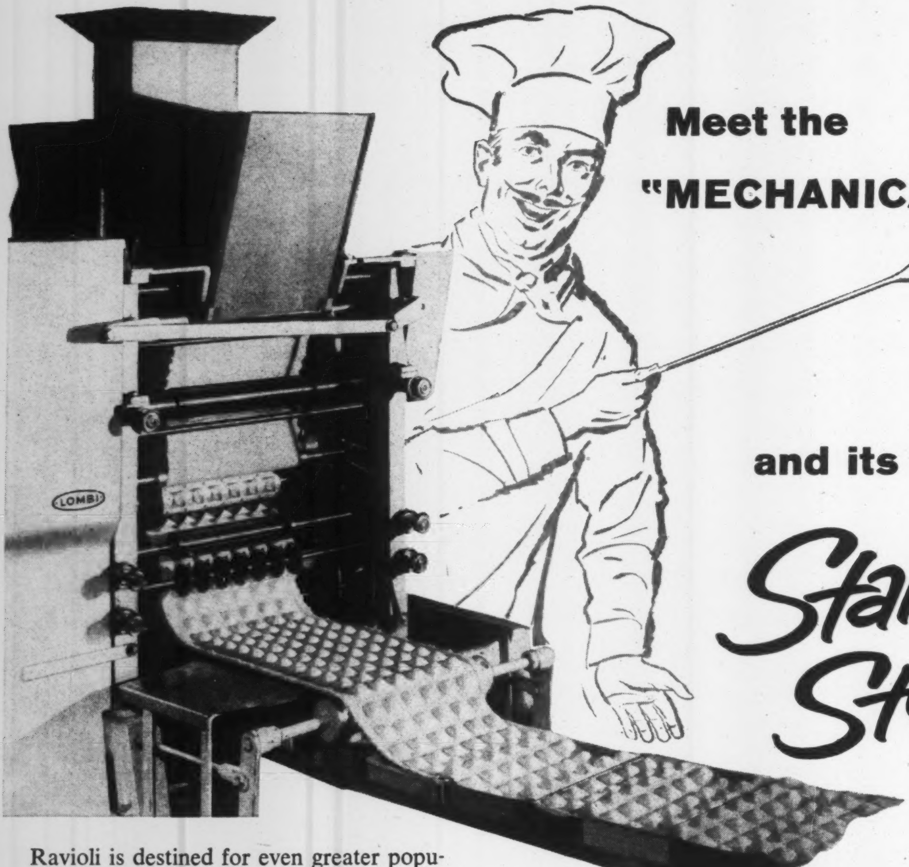

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plus Alloy Sulphides

TYPICAL MECHANICAL PROPERTIES

Furnished Hardness	RC 42-46
Ultimate Strength, psi	200,000
Yield Strength (0.2% offset) psi	175,000
Reduction of area, %	42
Elongation, 2″ —%	12
Coefficient of Expansion 80-1000°F	7.0×10^{-6}

More and more machine tool components and maintenance parts are being made of Latrobe's prehardened VISCOUNT 44. Why? Because this steel is easy to machine—has unexcelled strength, good toughness and exceptional wearing qualities. Suitable for parts operating up to temperatures of 1000°F. Prehardened, Viscount 44 eliminates risk of size change and distortion resulting from heat treatment.

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J&L offers you a specialized organization devoted exclusively to strip steel processing combined with fully integrated melting facilities.

Precise control of hardness, analysis, microstructure, gauge and finish—to your specifications—gives you the consistent quality needed for your most critical applications.

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Gauge .001"–.135". Width ¼"–23-15/16". Finishes 2, 3. Edges 1, 3, 5. Available in all hardness ranges.

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Gauge .0015"–.062". Width ½"–9". Finishes: Scaleless blue, bright tempered unpolished, tempered and polished or tempered, polished blue or straw colored. Carbon .61% to 1.35%.

ELECTROLYTIC COATINGS:

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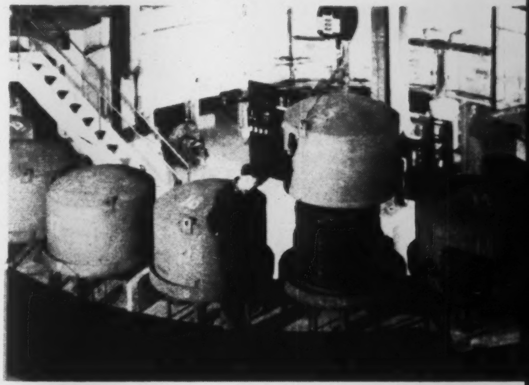

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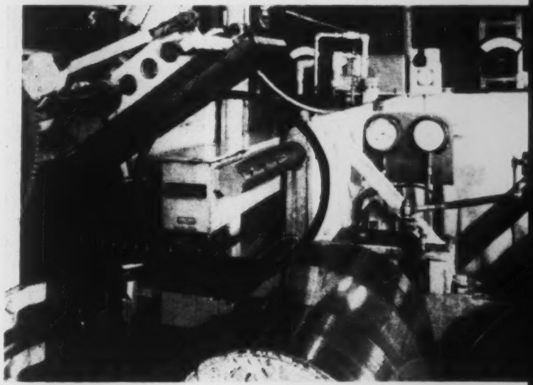
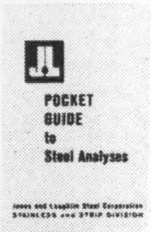


Typical of J&L precise control methods is this AccuRay thickness gauge to help assure close tolerances on cold rolled strip steels.



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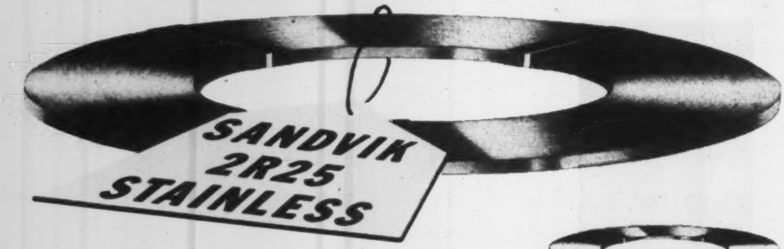
SANDVIK

Presents A SUPER SPRING STEEL



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MODULUS OF ELASTICITY—27.7 to 35.6 x 10^6 PSI according to size and finish
SIZES (with extremely close tolerances)
Thickness—.0016" to .035", Width—.039" to 3.94"
For further information on Sandvik 2R25, contact your nearest Sandvik office.

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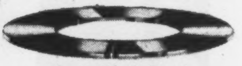
Razor Blade Steel

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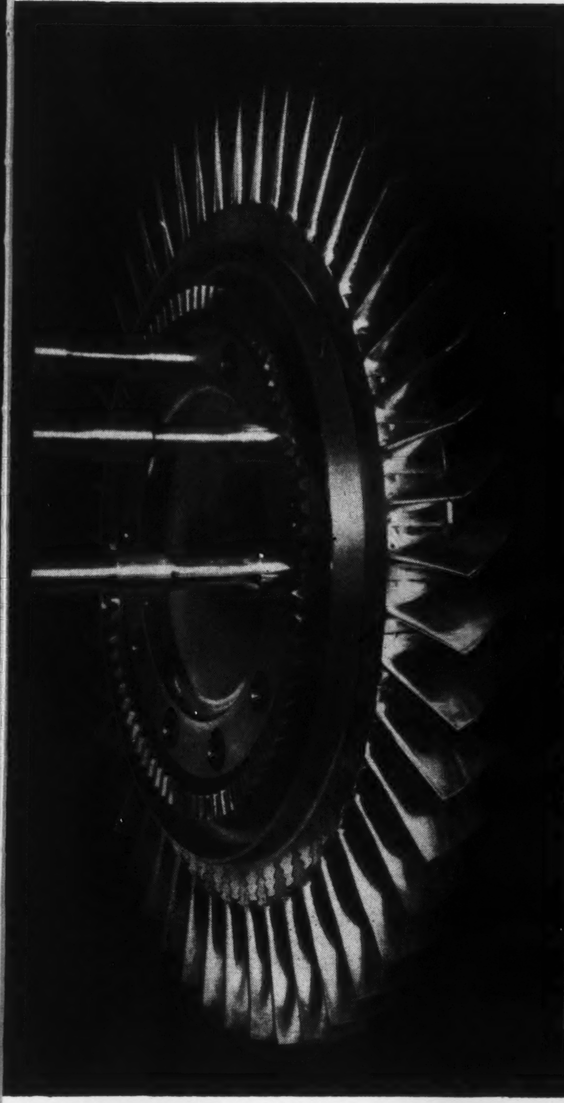
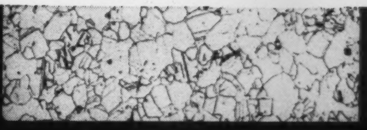
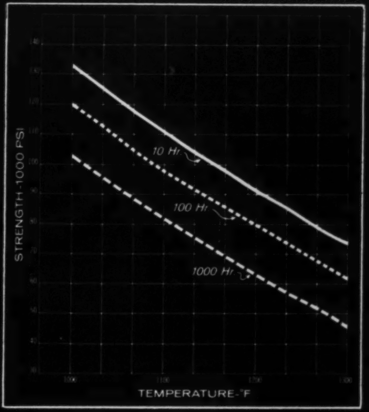
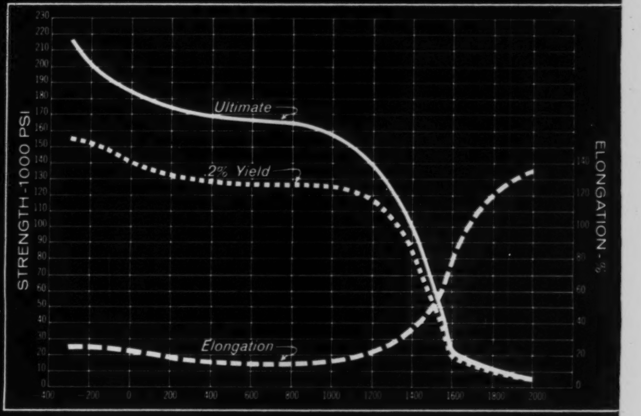






W-545 STRESS RUPTURE
STRENGTH vs. TEMPERATURE



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SUPPLIERS' LITERATURE

Nonferrous Metals

Cryogenic Uses of Aluminum. Aluminum Co. of America, 24 pp, illus. Discusses the use of aluminum in such cryogenic applications as liquid nitrogen containers, heat exchangers, pipes and pipe assemblies. Gives properties of aluminum-magnesium alloys at subzero temperatures. **56**

Specifications for Copper Alloys. American Brass Co., 28 pp, No. B-34. Military, ASTM, SAE, AMS, ASME and AWS specifications for copper, brass, phosphor bronze, cupro-nickels, nickel silvers and leaded brasses. **57**

Bronze Casting Alloys. American Manganese Bronze Co., 50 pp, illus. Composition, characteristics and applications of the principal copper alloys used to make castings. **58**

Nonferrous Metal Powders. American Metal Climax, Inc., 16 pp, illus., No. C-14. Specifications, product description and uses for copper, tin and precious metal powders. **59**

Rare Earths. Lindsay Chemical Div., American Potash & Chemical Co., 12 pp, illus. Describes company's work in the rare earth field. **60**

Bearing Bronze Bars. American Smelting & Refining Co., Continuous-Cast Products Dept., 6 pp, illus., No. 301. Gives stock sizes and weights for solid and hollow continuous-cast bronze bars ½ to 9 in. in dia. **61**

Fusible Alloys. American Smelting & Refining Co., Federated Metals Div., 32 pp, illus. Properties and uses of low melting fusible alloys composed of two or more of the metallic elements bismuth, lead, tin, cadmium and indium. **62**

Aluminum Bronze. Ampco Metal Inc., 20 pp, illus., No. 33d. Chemical composition, physical and mechanical properties, and uses of aluminum bronze alloys. Information also on sand and centrifugal castings, extrusions, forgings, and sheet and plate made of these alloys. **63**

Die Castings Alloys. Apex Smelting Co., 7 pp, illus. Design information, mechanical and physical properties, and chemical composition of aluminum, magnesium and zinc die casting alloys **64**

Grain Size of Brass. Bridgeport Brass Co., 6 pp, illus. Tells how correct grain size of brass can reduce finishing costs. Also describes how grain size of brass strip is affected by annealing and cold rolling. **65**

Magnesium-Thorium Alloys. Brooks & Perkins, Inc., 12 pp, illus. Mechanical and chemical properties, fabrication, forming characteristics, radioactivity and toxicity of magnesium-thorium alloys. **66**

Beryllium Metal. Brush Beryllium Co., 24 pp, illus. Information on strength, corrosion resistance, machinability, and electrical and optical properties of beryllium metal. **67**

Nickel-Base Alloy. Cannon-Muskegon Corp., 9 pp, illus., No. 86. Thermal conductivity, oxidation resistance, formability, and yield and tensile strength of a vacuum melted nickel-base alloy called René 41. **68**

Zirconium. Carborundum Metals Co., Div. of Carborundum Co., 8 pp, illus. "More Zr Facts," Vol. 1, discusses the corrosion resistance properties of zirconium. **69**

Low Melting Alloys. Cerro De Pasco Sales Corp., 8 pp, illus., No. J4. Sixty-three applications of low melting Cerro Alloys in the metalworking field. **70**

Brass Products. Titan Metal Mfg. Co., Div. of Cerro de Pasco Sales Corp., 24 pp, illus. Dimensional data, properties, weights and uses of brass and bronze bars, rectangles, squares and wire. **71**

Pure Chromium Metal. Chromalloy Corp., 4 pp, illus., No. 30. Suggested applications, chemical composition and fabricating characteristics of a 99.997% pure chromium metal called Iochrome. **72**

Titanium Aircraft Parts. Crucible Steel Co. of America, Titanium Div., 8 pp, illus., No. 2. Recent issue of "Titanium Review" discusses present and future uses of titanium in aircraft power plants. Also discusses heat treatment of B-120VCA titanium alloy. **73**

Magnesium Alloys. Dow Chemical Co., Magnesium Dept., 26 pp, illus., No. 141-187. Characteristics, design information, fabrication data and high temperature properties of various magnesium-thorium alloys. **74**

Resistance Alloy. Wilbur B. Driver Co., 8 pp, illus. Describes manufacture and uses of Evanohm, a nickel-chromium-aluminum-copper alloy used in electrical resistance wire. **75**

Resistance Alloys. Driver-Harris Co., 4 pp, illus., Vol. 18, No. 4. Use of electrical resistance alloys in appliances, radiant heaters, welding machines and heat treating furnaces. **76**

Precious Metals. Engelhard Industries, Inc., D. E. Makepeace Co. Div., illus. Describes solid and laminated precious and base metals for chemical and electrical equipment. **77**

Aluminum Sheet, Coils. Fairmont Aluminum Co., 4 pp. Physical properties, weights, dimensional data and uses of aluminum sheet, coils and circles. **78**

Tantalum Sheet, Foil. Fansteel Metallurgical Corp., Metals & Fabrication Div., 6 pp, No. 2.602-1. Ordering data, prices, sizes and tolerances for tantalum sheet and foil. **79**

Aluminum Casting Alloy. Frontier Bronze Corp., 24 pp, illus. Describes Alloy 40-E, a high strength aluminum casting alloy that needs no heat treatment. **80**

Electrical Contact Materials. Gibson Electric Co., 4 pp, illus., No. 601. Properties, available forms and uses of silver, palladium-nickel, silver-graphite and silver-tungsten electrical contact materials. **81**

Nonferrous Metal Powders. Glidden Co., Chemicals-Pigments-Metals Div., 6 pp. Information on lead and Resistox copper powders. **82**

Indium Alloys. Indium Corp. of America, 93 pp, graphs. Constitution of indium alloy systems. **83**

Aluminum Products. Kaiser Aluminum & Chemical Sales, Inc., 24 pp, illus. Physical and mechanical properties, chemical composition and uses of wrought aluminum alloys available as sheet, plate, foil, rod, bar, wire, extrusions and tubing. **84**

Nickel-Base Alloy. Kelsey-Hayes Co., Metals Div., 16 pp, illus. Forms, uses, composition, physical properties, heat treatment and machining of Udimet 500, a nickel-base high temperature alloy. Graphs give stress-rupture, creep and fatigue properties. **85**

Contact Materials. Leach & Garner Co., Industrial Div., 4 pp. Information on gold, silver, palladium, platinum and copper alloys for use as contact materials. **86**

Alloy Wires. Little Falls Alloys, Inc. Three folders give information on physical, chemical and electrical properties of nickel clad titanium, bronze, brass and beryllium copper wire. **87**

Magnesium Casting Alloy. Magnesium Elektron Inc., 12 pp, illus. Tensile, and short-time and long-time creep and fatigue properties of a high strength magnesium casting alloy. **88**

Titanium. Mallory-Sharon Metals Corp., 24 pp, illus. Advantages, properties, metallurgy, corrosion resistance, machinability and weldability of titanium. **89**

Rare Earths. Michigan Chemical Corp., Rare Earths & Thorium Div., 14 pp. Properties, uses and specifications of such rare earths as samarium, europium, gadolinium, terbium, yttrium, erbium, lutetium and holmium oxides. **90**

Phosphor Bronze. Miller Co., Rolling Mill Div., 4 pp, illus. Composition, properties, uses and availability of phosphor bronze coils and flat lengths. **91**

Aluminum Bronze. Mueller Brass Co., 7 pp, illus. Chemical and mechanical properties and uses of Tuf-Stuf aluminum bronze. **92**

Zirconium Metal. Zirconium Metals Corp. of America, Div. of National Lead Co., 5 pp. Composition, corrosion resistance, mechanical properties, machinability and uses of reactor and commercial grades of zirconium metal. **93**

Wrought Copper. Metals Div. of Olin Mathieson Chemical Corp., 14 pp, illus. Corrosion resistance, composition, available forms and physical properties of wrought copper and copper-base alloys. **94**

Nonferrous, Ferrous Wire. Riverside-Alloy Metal Div., H. K. Porter Co., Inc., 6 pp, illus. Sizes, tempers and characteristics of nonferrous and ferrous wire. **95**

Aluminum Mill Products. Reynolds Metals Co., 18 pp, illus. Tempers and sizes of sheet, plate, foil, wire, rod, bar, tubing, pipe, and extruded and structural shapes made of heat treatable and non-heat treatable aluminum alloys. **96**

Brass Strip, Sheet. Scovill Mfg. Co., 4 pp, illus. Information on continuous-cast strip and sheet brasses and bronzes. **97**

Tin-Plated Nonferrous Strips. Somers Brass Co., 1 p, illus. Data and specification sheet covering tin plating of a wide range of nonferrous thin metal strips. **98**

Tungsten. Sylvania Electric Products, Inc., Chemical & Metallurgical Div., 20 pp, illus. Chemical, physical and electrical properties of tungsten. Information on tungsten rod and wire. **99**

Properties of Tin. Tin Research Institute, Inc., 55 pp, illus. Physical, mechanical, nuclear and chemical properties of tin. **100**

Corrosion Resistant Alloy. Haynes Stellite Co., Div. of Union Carbide Corp., 16 pp, illus. Corrosion resistance, chemical composition, physical properties, hardness, formability, impact strength and short-time tensile strength for a nickel-base alloy called Hastelloy C. **101**

Ductile Vanadium Metal. Union Carbide Metals Co., Div. of Union Carbide Corp., 2 pp, illus. Heat resistance, fabricating data, physical and mechanical properties, and uses of ductile vanadium metal. **102**

Vanadium Metal. Vanadium Corp. of America, 6 pp. Physical and mechanical properties, machinability, formability and weldability of high purity vanadium metal. **103**

Tungsten. Wah Chang Corp., 5 pp. Physical and mechanical properties, chemical resistance, fabrication and uses of tungsten. **104**

Nonferrous Sheet, Strip. Waterbury Rolling Mills, Inc., 62 pp, illus. Composition, physical and mechanical properties and machinability of eight different nickel silvers, four phosphor bronzes and three special copper-base alloys available as sheet, strip and coils. **105**

Cadmium, Lead and Tin Products. White Metal Rolling & Stamping Corp., 4 pp. Properties and uses of cadmium, lead and tin sheet, plate, strip, wire and rod. **106**

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Aluminum and Its Alloys—Wrought

Type ➡	EC	1100	3003	3004
COMPOSITION, %	Al 99.45 min	Al 99.0 min	Mn 1.0–1.5	Mn 1.0–1.5, Mg 0.8–1.3
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.098	0.098	0.099	0.098
Melting Temp Range, F	1195–1215	1190–1215	1190–1210	1165–1205
Ther Cond (77 F, ann.), Btu/hr/sq ft/°F/ft	135	128	111	93.8
Coef of Ther Exp (68 to 212 F), per °F	13.2×10^{-6}	13.1×10^{-6}	12.9×10^{-6}	12.9×10^{-6}
Spec Heat (212 F), Btu/lb/°F	—	0.22	0.22	0.22
Elec Res (68 F), microhm-cm				
Annealed	2.8	2.92	3.45	4.10
Hard (H18 or H38)[a]	—	3.02	4.31	4.10
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	10×10^6	10×10^6	10×10^6	10×10^6
Ten Str (75 F), 1000 psi				
Annealed (O)	12	13	16	26
Half Hard	16 (H14)	18 (H14)	22 (H14)	35 (H34)
Hard	27 (H19)	24 (H18)	29 (H18)	41 (H38)
Yld Str (75 F), 1000 psi				
Annealed (O)	4	5	6	10
Half Hard	14 (H14)	17 (H14)	21 (H14)	29 (H34)
Hard	24 (H19)	22 (H18)	27 (H18)	36 (H38)
Elong (in 2 in., 75 F), %[a]				
Annealed (O)	23[d]	35, 45	30, 40	20, 25
Half Hard	—	9, 20 (H14)	8, 16 (H14)	9, 12 (H34)
Hard	1.5[d] (H19)	5, 15 (H18)	4, 10 (H18)	5, 6 (H38)
Hardness (Brinell)[b]				
Annealed (O)	—	23	28	45
Half Hard	—	32 (H14)	40 (H14)	63 (H34)
Hard	—	44 (H18)	55 (H18)	77 (H38)
Endurance Limit, 1000 psi				
Annealed (O)	—	5	7	14
Half Hard	—	7 (H14)	9 (H14)	15 (H34)
Hard	7 (H19)	9 (H18)	10 (H18)	16 (H38)
Shear Str, 1000 psi				
Annealed (O)	8	9	11	16
Half Hard	10 (H14)	11 (H14)	14 (H14)	18 (H34)
Hard	15 (H19)	13 (H18)	16 (H18)	21 (H38)
FABRICATING PROPERTIES				
Annealing Temp, F	650	650	775	650
Hot Working Temp Range, F	—	500–950	500–950	500–950
Machinability	Fair	Good	Good	Good
Relative Weldability[c]				
Torch	—	A	A	B
Inert Arc	A	A	A	A
Electrical Resistance	—	A	A	A
CORROSION RESISTANCE	High resistance to rural, industrial and marine atmospheres. Good resistance to most neutral or nearly neutral fresh waters; sea water; many foodstuffs; organic acids and anhydrides; alcohols; aldehydes; esters; ketones; oils, gasoline, greases, waxes, and other petroleum derivatives; ammonia and ammonium compounds; nitric acid above 82%; essential oils; amides; nitroparaffins; coal tar derivatives; hydrogen peroxide; and many neutral aqueous inorganic salt solutions			
AVAILABLE FORMS	Sheet, plate, wire, rod, bar			
	Foil, extrusions	Rivets, forgings, impact extrusions	Extruded shapes, tubing, forgings	Sheet, plate
USES	Electrical conductors	Cooking utensils, heat exchangers, pressure and storage tanks		Hydraulic tubing for commercial vehicles, storage tanks
		Chemical equipment, reflectors	Ductwork, truck panels, architectural applications, builders' hardware	

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[a] Values given for 1/16-in. sheet and ½-in. bar, in that order.

[b] 500-kg load, 10-mm ball.

[c] Letter A indicates most favorable, B less favorable, etc. Values relative to aluminum alloys only.

[d] Elongation (in 10 in.) for wire.

Aluminum and Its Alloys—Wrought

Type ➡	2011	2014[a, b]	2017	2024[c]
COMPOSITION, %	Cu 5.0–6.0, Pb 0.2–0.6, Bi 0.2–0.6	Cu 3.9–5.0, Si 0.5–1.2, Mn 0.4–1.2, Mg 0.2–0.8	Cu 3.5–4.5, Mn 0.4–1.0, Mg 0.2–0.8	Cu 3.8–4.9, Mn 0.3–0.9, Mg 1.2–1.8
PHYSICAL PROPERTIES				
Density, lb/cu in	0.102	0.101	0.101	0.100
Melting Temp Range, F	995–1190	950–1180	955–1185	935–1180
Ther Cond (77 F, annealed), Btu/hr/sq ft/°F/ft	81.7	111.0	99.4	111.0
Coef of Ther Exp, per °F				
68 to 212 F	12.8×10^{-6}	12.5×10^{-6}	12.7×10^{-6}	12.6×10^{-6}
68 to 572 F	13.9×10^{-6}	13.6×10^{-6}	13.9×10^{-6}	13.7×10^{-6}
Spec Heat, Btu/lb/°F	0.23	0.22	0.22	0.22
Elec Res (68 F), microhm-cm	4.31 (T3)	3.45 (O), 4.31 (T6)	3.83 (O), 5.75 (T4)	3.45 (O), 5.75 (T4)
MECHANICAL PROPERTIES[d]				
Mod of Elast in Tension, psi	10.2×10^6	10.6×10^6	10.5×10^6	10.6×10^6
Ten Str, 1000 psi				
Annealed (O)	—	27	26	27
Heat Treated	55 (T3), 59 (T8)	62 (T4), 70 (T6)	62 (T4)	70 (T3)
Yld Str (0.2% offset), 1000 psi				
Annealed (O)	—	14	10	11
Heat Treated	43 (T3), 45 (T8)	42 (T4), 60 (T6)	40 (T4)	50 (T3)
Elong (in 2 in.), %				
Annealed (O)	—	18	22	20[e]
Heat Treated	15 (T3), 12 (T8)	20 (T4), 13 (T6)	22 (T4)	18 (T3)[e]
Hardness (Brinell)				
Annealed (O)	—	45	45	47
Heat Treated	95 (T3), 100 (T8)	105 (T4), 135 (T6)	105 (T4)	120 (T3)
Endurance Limit, 1000 psi				
Annealed (O)	—	13	13	13
Heat Treated	18 (T3), 18 (T8)	20 (T4), 18 (T6)	18 (T4)	20 (T3)
Shear Str, 1000 psi				
Annealed (O)	—	18	18	18
Heat Treated	32 (T3), 35 (T8)	38 (T4), 42 (T6)	38 (T4)	41 (T3)
FABRICATING PROPERTIES				
Annealing Temp, F	775	775	775	775
Solution Temp, F	950	940	940	920
Aging Temp, F	320	340	—	375
Machinability[e]	A (T3, T8)	A (T6)	A (T4)	A (T3)
Relative Weldability[e]				
Torch	D	D	D	D
Inert Arc	D	B	B	B
Electrical Resistance	D	B	A	B
CORROSION RESISTANCE	Compared to other aluminum alloys, this group has high resistance to rural atmospheres, fairly good resistance to industrial atmospheres, and poor resistance to marine atmospheres and sea water. More susceptible to corrosive attack than other groups of wrought aluminum alloys. Both degree and nature of the attack are greatly influenced by thermal treatment. Clad sheet alloys generally have high corrosion resistance			
AVAILABLE FORMS	Rod, hexagon bar, wire	Extruded shapes, rolled shapes, forgings, rod, bar	Rod, bar, wire	Sheet, plate, rod, bar, tubing, wire, rivets, extruded shapes
USES	Screw machine products	Heavy duty forgings, power shovel bails, airplane fittings, structural members	Screw machine products	Screw machine products

[a] 2014 available clad with 6053.

[b] Similar to 2014 is Hardclad 301. Core: 4.0-5.0 Cu, 0.75-1.2 Si, 0.70-1.0 Mn, 0.25-0.55 Mg. Claddings: 0.50-0.90 Si, 0.25-0.75 Mn, 0.80-1.2 Mg.

[c] 2024 available clad with aluminum of 99.3% min purity.

[d] Values given on 1/16-in. sheet and 1/2-in. bar, in that order.

[e] Letter A indicates most favorable, B less favorable, etc. Relative to aluminum alloys only.

continued on next page

Aluminum and Its Alloys—Wrought

Type →	5005	5050	5052	5056
COMPOSITION, %	Mg 0.8	Mg 1.0–1.8	Mg 2.2–2.8, Cr 0.15–0.35	Mn 0.05–0.20, Mg 4.7–5.6, Cr 0.05–0.20
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.097	0.097	0.097	0.095
Melting Temp Range, F	1160–1205	1160–1205	1100–1200	1055–1180
Ther Cond (77 F, ann.), Btu/hr/sq ft/°F/ft	111	111	79.2	67.4
Coef of Ther Exp, per °F				
68 to 212 F	13.3 x 10^{-6}	13.2 x 10^{-6}	13.2 x 10^{-6}	13.4 x 10^{-6}
68 to 572 F	—	14.2 x 10^{-6}	14.3 x 10^{-6}	14.5 x 10^{-6}
Spec Heat (212 F), Btu/lb/°F	0.23	0.22	0.22	0.22
Elec Res (68 F), microhm-cm				
Annealed	3.4	—	4.93	5.94
Hard (H18 or H38)[a]	—	—	4.93	6.39
MECHANICAL PROPERTIES				
Mod of Elasticity in Tension, psi	10 x 10^{6}	10 x 10^{6}	10.2 x 10^{6}	10.3 x 10^{6}
Ten Str (75 F), 1000 psi				
Annealed (O)	18	21	28	42
Half Hard	23 (H14)	28 (H34)	38 (H34)	—
Hard	29 (H18)	32 (H38)	42 (H38)	60 (H38)
Yld Str (75 F), 1000 psi				
Annealed (O)	6	8	13	22
Half Hard	22 (H14)	24 (H34)	31 (H34)	—
Hard	28 (H18)	29 (H38)	37 (H38)	50 (H38)
Elong (in 2 in., 75 F), %[a]				
Annealed (O)	30, —	24	25, 30	—, 35
Half Hard	6, — (H14)	8 (H34)	10, 14 (H34)	—
Hard	4, — (H18)	6 (H38)	7, 8 (H38)	—, 15 (H38)
Hardness (Brinell)[b]				
Annealed (O)	28	36	47	65
Half Hard	41 (H14)	53 (H34)	68 (H34)	—
Hard	51 (H38)	63 (H38)	77 (H38)	105(H18),100(H38)
Endurance Limit, 1000 psi				
Annealed (O)	—	12	16	20
Half Hard	—	13 (H34)	18 (H34)	—
Hard	—	14 (H38)	20 (H38)	22 (H38)
Shear Str, 1000 psi				
Annealed (O)	11	15	18	26
Half Hard	14 (H14)	18 (H34)	21 (H34)	—
Hard	16 (H18)	20 (H38)	24 (H38)	32 (H38)
FABRICATING PROPERTIES				
Annealing Temp, F	650	650	650	650
Hot Working Temp Range, F	—	—	500–950	500–950
Machinability	Good	Good	Good	Good
Relative Weldability[c]				
Torch	—	B	B	C
Inert Arc	—	A	A	A
Electrical Resistance	—	A	A	B
CORROSION RESISTANCE	High resistance to rural, industrial and marine atmospheres. Good resistance to most neutral or nearly neutral fresh waters; sea water; many foodstuffs; organic acids and anhydrides; alcohols; aldehydes; esters; ketones; oils, gasoline, greases, waxes, and other petroleum derivatives; ammonia and ammonium compounds; nitric acid above 82%; essential oils; amides; nitroparaffins; coal tar derivatives; hydrogen peroxide; and many neutral aqueous inorganic salt solutions			
AVAILABLE FORMS	Foil, sheet, plate	Sheet, plate, drawn tube	Sheet, plate, wire, rod, bar, drawn tubing	Rod, wire
USES	Appliances, cooking utensils, architectural applications	Decorative refrigerator parts, coiled tubes, builders' hardware	Bus and truck bodies, aircraft tubing, milk crates, fan blades, kitchen cabinets	Cable sheathing, rivets for magnesium

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[a] Values given for 1/16-in. sheet and 1/2-in. bar, in that order.
[b] 500-kg load, 10-mm ball.
[c] Letter A indicates most favorable, B less favorable, etc. Values relative to aluminum alloys only.

Aluminum and Its Alloys—Wrought

Type ➡	5083	5086	5154	5456
COMPOSITION, %	Mg 4.0–4.9, Mn 0.5–1.0, Cr 0.25 max	Mg 3.5–4.5, Mn 0.2–0.7, Cr 0.25 max	Mg 3.5, Cr 0.25	Mg 4.7–5.5, Mn 0.5–1.0, Cr 0.05–0.20
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.096	0.096	0.096	0.096
Melting Temp Range, F	1065–1180	1084–1184	1100-1190	—
Ther Cond (77 F, ann.), Btu/hr/sq ft/°F/ft	68	73	73	—
Coef of Ther Exp (68–212 F), per °F	13.2×10^{-6}	13.2×10^{-6}	13.3×10^{-6}	13.3×10^{-6}
Spec Heat (212 F), Btu/lb/°F	0.23	0.23	0.23	0.23
Elec Res (68 F), microhm-cm				
Annealed	5.9	5.5	5.3	5.9
Hard	—	5.5	5.3	—
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	10.3×10^6	10.3×10^6	10.2×10^6	10.3×10^6
Ten Str (75 F), 1000 psi				
Annealed (O)	42	38	35	45
Half Hard	46 (H113)	47 (H34)	42 (H34)	51 (H321)
Hard	—	—	48 (H38)	—
Yld Str (75 F), 1000 psi				
Annealed	21	17	17	23
Half Hard	33 (H113)	37 (H34)	33 (H34)	37 (H321)
Hard	—	—	39 (H38)	—
Elong (in 2 in., 75 F), %[a]				
Annealed (O)	22, —	22, —	27, —	24, —
Half Hard	16 (H113), —	10 (H34), —	13 (H34), —	16 (H321), —
Hard	—	—	10 (H38), —	—
Hardness (Brinell)[b]				
Annealed (O)	73	B16[d]	58	75
Half Hard	—	B44[d]	78 (H34)	90 (H321)
Hard	—	—	87 (H38)	—
Endurance Limit, 1000 psi				
Annealed (O)	—	—	17	—
Half Hard	23 (H113)	16 (H34)	19 (H34)	—
Hard	—	—	21 (H38)	—
Shear Str, 1000 psi				
Annealed (O)	25	23	22	28
Half Hard	—	27 (H34)	24 (H34)	30 (H321)
Hard	—	—	28 (H38)	—
FABRICATING PROPERTIES				
Annealing Temp, F	650	650	650	—
Machinability	D	D	D	D
Relative Weldability[c]				
Torch	D	C	C	D
Inert Arc	A	A	A	A
Electrical Resistance	B	B	B	B
CORROSION RESISTANCE	High resistance to rural, industrial and marine atmospheres. Good resistance to most neutral or nearly neutral fresh waters; sea water; many foodstuffs; organic acids and anhydrides; alcohols; aldehydes; esters; ketones; oils, gasoline, greases, waxes, and other petroleum derivatives; ammonia and ammonium compounds; nitric acid above 82%; essential oils; amides; nitroparaffins; coal tar derivatives; hydrogen peroxide; and many neutral aqueous inorganic salt solutions			
AVAILABLE FORMS	Plate, extrusions, sheet, structural shapes, bar, rod	Sheet, plate, extrusions, structural shapes	Sheet, plate, welding wire, pipe, rod, bar	Sheet, plate, extrusions, rods, bar, structural shapes
USES	Unfired pressure vessels, marine superstructures, decks and hulls, auto frames, aircraft landing gears, TV structural towers, drilling rigs, welded assemblies	Transportation equipment, welded construction, unfired pressure vessels, guided missile containers	Unfired pressure vessels, welded construction, storage tanks, truck and marine applications	Deck housing, heavy duty structures, overhead cranes, gun mounts, pressure vessels, storage tanks

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[a] Values given for 1/16-in. sheet and ½-in. bar in that order. [b] 500-kg load, 10-mm ball.
[c] Letter A indicates most favorable, B less favorable, etc. Values relative to aluminum alloys only.
[d] Rockwell hardness. [e] Elongation (in 10 in.) for wire.

continued on next page

Aluminum and Its Alloys—Wrought

Type ➔	6061	6063	7075	7079
COMPOSITION, %	Mg 0.8–1.2, Si 0.4–0.8, Cr 0.15–0.35, Cu 0.15–0.40	Mg 0.45–0.9, Si 0.2–0.6	Zn 5.1–6.1, Mg 2.1–2.9, Cu 1.2–2.0, Cr 0.18–0.40	Zn 3.8–4.8, Mg 2.9–3.7, Cu 0.4–0.8, Mn 0.1–0.3, Cr 0.1–0.25
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.098	0.098	0.101	0.099
Melting Temp Range, F	1080–1200	1140–1205	890–1180	900–1180
Ther Cond (77 F), Btu/hr/sq ft/°F/ft	99	111	70 (T6)	70 (T6)
Coef of Ther Exp, per °F				
68–212 F	13.0 x 10^{-6}	13.0 x 10^{-6}	12.9 x 10^{-6}	13.1 x 10^{-6}
68–572 F	14.1 x 10^{-6}	14.2 x 10^{-6}	14.4 x 10^{-6}	14.2 x 10^{-6}
Specific Heat, Btu/lb/°F	0.23	—	0.23	—
Elec Res (68 F), microhm-cm	3.8 (O)	3.1 (T6)	5.7 (T6)	5.5 (T6)
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	10.0 x 10^{6}	10.0 x 10^{6}	10.4 x 10^{6}	10.3 x 10^{6}
Ten Str, 1000 psi				
Annealed (O)	18	13	33	—
Heat Treated	35 (T4), 45 (T6)	25 (T4), 35 (T6)	83 (T6)	78 (T6)
Yld Str (0.2% offset), 1000 psi				
Annealed (O)	8	7	15	—
Heat Treated	21 (T4), 40 (T6)	13 (T4), 31 (T6)	73 (T6)	68 (T6)
Elong (in 2 in.), %				
Annealed (O)	25	—	17	—
Heat Treated	22 (T4), 12 (T6)	22 (T4), 12 (T6)	11 (T6)	14 (T6)
Hardness (Brinell)				
Annealed (O)	30	25	60	—
Heat Treated	65 (T4), 95 (T6)	—, 73 (T6)	150 (T6)	145 (T6)
Endurance Limit, 1000 psi				
Annealed (O)	9	8	—	—
Heat Treated	14 (T4), 14 (T6)	—, 10 (T6)	23 (T6)	23 (T6)
Shear Str, 1000 psi				
Annealed (O)	12	10	22	—
Heat Treated	24 (T4), 30 (T6)	—, 22 (T6)	48 (T6)	45 (T6)
FABRICATING PROPERTIES				
Annealing Temp, F	775	775	775	—
Solution Temp, F	970	—	880	830
Aging Temp, F	340	350–450	250	240–250
Machinability[a]	B (T4, T6)	B (T4, T6)	A (T6)	A (T6)
Relative Weldability[a]				
Torch	A	A	D	D
Inert Arc	A	A	C	C
Elec Res	A	A	C	C
CORROSION RESISTANCE	Compared with other aluminum alloys, these alloys have high resistance to rural atmospheres, good resistance to industrial and marine atmospheres. Degree and nature of attack in other environments is greatly influenced by heat treatment. Clad alloys have corrosion resistance of the cladding alloy		Compared with other aluminum alloys, these alloys have good corrosion resistance to rural atmospheres but are attacked by industrial and marine atmospheres. In other environments, they are generally less corrosion resistant than other wrought aluminum alloys and are frequently clad. Clad alloys have corrosion resistance of the cladding alloy	
AVAILABLE FORMS	Sheet, plate, wire, rod, bar, pipe, tubing, rolled and extruded shapes forgings	Extruded shapes, tube, pipe	Sheet, plate, wire, rod, bar, extruded shapes, tube, pipe, forgings	Forgings, extrusions, sheet, plate
USES	Transportation equipment, heavy duty structures, marine uses, pipe, furniture	Pipe, railings, hardware, architectural uses	Structural parts for aircraft	

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[a] Letter A indicates most favorable, B less favorable, etc. Relative to aluminum alloys only.

Aluminum and Its Alloys—Cast

ASTM Type ➜	C4A	CS42A	CS43A	SC64A
COMPOSITION, %	Cu 4.5, Al bal	Cu 4.5, Si 2.5, Al bal	Cu 4.0, Si 3.0, Al bal	Cu 4.5, Si 5.5, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.101	0.100	0.100	0.100
Solid. Temp Range, F	1195–1020	1160–980	1160–970	1140–960
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	82.5	92.5	70	82
Coef of Ther Exp (68–212 F), per °F	12.7×10^{-6}	12.2×10^{-6}	12.2×10^{-6}	11.9×10^{-6}
Elec Cond (as cast), % IACS	36	42.5	31	37
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
As Cast	—	—	19	28
Sol'n Heat Treated	32	37	—	—
Sol'n Treated & Aged	40	40	—	—
Yld Str (0.2% offset), 1000 psi				
As Cast	—	—	14	16
Sol'n Heat Treated	16	22	—	—
Sol'n Treated & Aged	30	26	—	—
Elong (in 2 in.), %				
As Cast	—	—	1.5	2.0
Sol'n Heat Treated	8.5	9.0	—	—
Sol'n Treated & Aged	2.0	5.0	—	—
Hardness (Brinell)				
As Cast	—	—	—	70
Sol'n Heat Treated	60	75	—	—
Sol'n Treated & Aged	95	90	—	—
Endurance Limit, 1000 psi				
Sol'n Heat Treated	6	9.5	—	—
Sol'n Treated & Aged	7	—	—	—
Compr Yld Str, 1000 psi				
As Cast	—	—	—	16
Sol'n Heat Treated	16	22	—	—
Sol'n Treated & Aged	38	26	—	—
Shear Str, 1000 psi				
As Cast	—	—	—	25
Sol'n Heat Treated	24	30	—	—
Sol'n Treated & Aged	31	32	—	—
THERMAL TREATMENT				
Annealing Temp, F	650	650	650	650
Solution Temp, F	960	960	960	940
Aging Temp, F	310	310	310	310
FABRICATING PROPERTIES				
Machinability[e]	AB	AB	C	C
Weldability[e]				
Gas	C	C	B	A
Arc	B	B	D	A
Resistance	B	B	B	A
CORROSION RESISTANCE	Good corrosion resistance; alloys containing silicon are superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Sand castings	Permanent mold castings	Sand castings	Permanent mold castings
USES	Crankcases, bus wheels, housings, spring hangers, fittings	Aircraft fittings, fuel pump bodies, gear housings, seat frames	Manifolds, valve bodies, pressure-tight parts	Parts requiring pressure tightness

[a] General purpose castings. [e] A = excellent, AB = very good, B = good, C = fair, D = poor.

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Aluminum and Its Alloys—Cast

ASTM Type ➡	G4A	G10A	S5A	SG70A
COMPOSITION, %	Mg 4.0, Al bal	Mg 4.0, Al bal	Si 5.25, Al bal	Si 7.0, Mg 0.35, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.095	0.093	0.097	0.096
Solid. Temp Range, F	1185–1075	1150–840	1175–1070	1130–1075
Ther Cond (as cast, 68F), Btu/hr/sq ft/°F/ft	80	51	85	92
Coef of Ther Exp (68–212 F), per °F	13.3×10^{-6}	13.6×10^{-6}	12.2×10^{-6}	11.9×10^{-6}
Elec Cond (as cast), % IACS	35	21	38	41
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
As Cast	25	—	19	—
Sol'n Heat Treated	—	46	—	—
Aged[g]	—	—	—	25, 40
Yld Str (0.2% offset), 1000 psi				
As Cast	12	—	9	—
Sol'n Heat Treated	—	25	—	—
Aged[g]	—	—	—	20, 27
Elong (in 2 in.), %				
As Cast	9.0	—	6.0	—
Sol'n Heat Treated	—	14	—	—
Aged[g]	—	—	—	2.0, 5.0
Hardness (Brinell)				
As Cast	50	—	40	—
Sol'n Heat Treated	—	75	—	—
Aged[g]	—	—	—	60, 90
Endurance Limit, 1000 psi				
As Cast	5.5	—	6.5	—
Sol'n Heat Treated	—	7	—	—
Compr Yld Str, 1000 psi				
As Cast	12	—	10	—
Sol'n Heat Treated	—	26	—	—
Aged[g]	—	—	—	28, 24
Shear Str, 1000 psi				
As Cast	20	—	14	—
Sol'n Heat Treated	—	33	—	—
THERMAL TREATMENT				
Annealing Temp, F	650	650	650	650
Solution Temp, F	950	960	960	1000
Aging Temp, F	310	310	310	310
FABRICATING PROPERTIES				
Machinability[e]	A	A	C	A
Weldability[e, f]				
Gas	B	D	A, —	A, A
Arc	A	C	A, —	A, A
Resistance	B	B	A, —	A, A
CORROSION RESISTANCE	Very good corrosion resistance; alloys containing silicon are superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Sand castings	Sand castings	Sand and perm mold castings	Sand and perm mold castings
USES	Dairy and food handling equipment, cooking utensils, chemical fittings, hardware	Aircraft fittings, levers, brackets, parts requiring shock resistance	Sand—marine fittings, food handling equipment, pipe fittings. Permanent mold — refrigerator fittings, carburetor bodies, thin-section general purpose castings	Sand—automotive transmission cases, housings, aircraft fittings

[b] Corrosion resistant castings. [e] A = excellent, AB = very good, B = good, C = fair, D = poor.

[f] Where two values are given they refer to sand and permanent mold castings, respectively.

[g] First value obtained by artificial aging; second value by solution treating and aging.

Aluminum and Its Alloys—Cast

ASTM Type ➡	CG100A	CN42A	SC51A
COMPOSITION, %	Cu 10.0, Mg 0.25, Al bal	Cu 4.0, Mg 1.5, Ni 2.0, Al bal	Cu 1.25, Si 5.0, Mg 0.5, Al bal
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.103	0.101	0.097
Solid. Temp Range, F	1160–1005	1165–995	1160–1070
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	77	87	87
Coef of Ther Exp (68–212 F), per °F	12.2×10^{-6}	12.5×10^{-6}	—
Elec Cond (as cast), % IACS	34	38.5	39
MECHANICAL PROPERTIES			
Tensile Strength, 1000 psi			
Artificially Aged	37	40	28
Sol'n Treated & Aged	48	47	43
Yield Strength (0.2% offset), 1000 psi			
Artificially Aged	35	34	23
Sol'n Treated & Aged	36	42	27
Elongation (in 2 in.), %			
Artificially Aged	0.5	1.0	1.5
Sol'n Treated & Aged	0.5	0.5	4.0
Hardness (Brinell)			
Artificially Aged	115	105	65
Sol'n Treated & Aged	140	110	90
Endurance Limit, 1000 psi			
Artificially Aged	8.5	10.5	7
Sol'n Treated & Aged	9	9.5	9
Compressive Yield Strength, 1000 psi			
Artificially Aged	40	34	24
Sol'n Treated & Aged	36	46	27
Shear Strength, 1000 psi			
Artificially Aged	27	26	22
Sol'n Treated & Aged	30	31	30
THERMAL TREATMENT			
Annealing Temp, F	650	650	650
Solution Temp, F	950	960	980
Aging Temp, F	310	310	310
FABRICATING PROPERTIES			
Machinability[e]	AB	AB	B
Weldability[e, f]			
Gas	C, D	C, C	A, A
Arc	B, C	B, B	A, A
Resistance	B, B	B, B	A, A
CORROSION RESISTANCE	Good corrosion resistance; alloy SC51A is superior. In general Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres		
AVAILABLE FORMS	Sand and permanent mold castings	Sand and permanent mold castings	Sand and permanent mold castings
USES	Sand—cylinder heads, bearing caps, bushings, tappet guides. Permanent mold—Meter parts, automotive pistons, bushings, bearings	Sand—cylinder heads, diesel engine pistons	Sand—cylinder heads, water jackets, housings, printing press bed plates. Permanent mold—aircraft supercharger impellers, timing gears, meter parts, rotors

[c] High temperature resistant castings.
[e] A = excellent, AB = very good, B = good, C = fair, D = poor.
[f] The two values refer to sand and permanent mold castings, respectively.

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Aluminum and Its Alloys—Cast

ASTM Type ➡	G8A	S5C	S12A	SC84A
COMPOSITION, %	Mg 8.0, Al bal	Si 5.25, Al bal	Si 12.0, Fe 1.3 max, Al bal	Cu 3.5, Si 8.5, Fe 1.3 max, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in	0.093	0.097	0.097	0.097
Solid. Temp Range, F	1150–995	1175–1070	1085–1065	1100–1000
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	56	84	70	58
Coef of Ther Exp (68–212 F), per °F	13.3×10^{-6}	12.2×10^{-6}	11.4×10^{-6}	11.7×10^{-6}
Elec Cond (as cast), % IACS	24	38	31	25
MECHANICAL PROPERTIES				
Ten Str, 1000 psi	45	30	39	46
Yld Str (0.2% offset), 1000 psi	27	16	21	25
Elong (in 2 in.), %	8.0	9.0	2.0	3.0
Endurance Limit, 1000 psi	23	17	19	19
Compr Yld Str, 1000 psi	27	16	21	25
Shear Str, 1000 psi	27	19	25	29
FABRICATING PROPERTIES				
Machinability[e]	A	C	A	AB
Weldability[e]				
Gas	D	B	D	D
Arc	D	B	D	D
Resistance	D	C	D	D
CORROSION RESISTANCE	Good corrosion resistance; alloys containing silicon are superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Die castings	Die castings	Die castings	Die castings
USES	Aircraft fittings and brake shoes, marine fittings, hardware	General purpose castings	Dental equipment, outboard motor pistons, typewriter frames	General purpose castings

[d] Die castings.

[e] A = excellent, AB = very good, B = good, C = fair, D = poor.

Cobalt and Its Alloys—Cast, Wrought

Type ➜	Cobalt		AMS 5385C	AMS 5537
COMPOSITION, %	Co 99.9	C 0.06–0.3, Co 98	C 0.20–0.35, Mn 1.0 max, Ni 1.5–3.5, Mo 4.5–6.5, Cr 25–30, Fe 2.0 max, Si 1.0 max, B 0.07 max	C 0.05–0.15, Mn 1.0–2.0, Ni 9–11, Cr 19–21, Fe 3.0 max, W 14–16, Si 1.0 max, Co 46–53
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.322	—	0.299	0.333
Melting Point, F	2723	—	2465	2570
Ther Cond, Btu/hr/sq ft/°F/ft	479	—	101 (392 F)	—
Coef of Ther Exp, per °F	6.8 x 10^{-6}	—	7.8 x 10^{-6}	—
Magnetic?	Yes	Yes	Yes	Yes
Curie Temperature, F	2039	—	—	—
Thermal Neutron Absorption, barns/atom	34.8	—	—	—
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	30 x 10^{6}	—	16.8 x 10^{6}[a]	35 x 10^{6}
Tensile Strength, 1000 psi				
Annealed	37	43–75	—	145–165
Sintered	98.5	—	—	—
Cold Worked	100	—	—	—
As Cast	34.4	61	103	—
Aged 50 hr at 1300 F	—	—	125	—
Yield Strength, 1000 psi				
Annealed	28–41	20–65	—	65–85
Sintered	43.8	—	—	—
As Cast	20–43	33	82	—
Aged 50 Hr at 1300 F	—	—	110	—
Elongation (in 2 in.), %				
Annealed	0–8	13	—	70–55
Sintered (1 in.)	13.5	—	—	—
Cold Worked	2–8	—	—	—
As Cast	0–4	5–30	8	—
Aged 50 Hr at 1300 F	—	—	2	—
Hardness (Brinell)				
Annealed	121–131[d]	138	—	225
Sintered (VHN)	173	—	—	—
As Cast	124–130	100–131	R_A65	—
Aged 50 Hr at 1300 F	—	—	R_A71	—
Compressive Strength, 1000 psi				
Annealed	117	140	—	—
As Cast	122	175	—	—
Mod of Elast in Shear, psi	11.1 x 10^{6}	—	—	—
Impact Strength, ft-lb				
Room Temp	—	—	2.9[b]	120[c]
1500 F	—	—	11[b]	—
THERMAL TREATMENT				
Annealing Temp, F	—	—	2175–2200	2225
Solution Temp, F	—	—	—	2200
Hardening Temp, F	—	—	1475–1500	—
FABRICATING PROPERTIES				
Hot Working Temp Range, F	930–1100	—	—	—
Machinability	Possible	Possible	Poor	Good
Weldability	—	—	Shield arc	Good
CORROSION RESISTANCE	Excellent	Excellent	Resistant to oxidizing media, flue gases	Highly resistant to scaling and oxidation at elevated temperatures
AVAILABLE FORMS	Rondelles, powders	Rondelles, powders	Precision castings, sand castings, bar, sheet, welding rod	Sheet, plate, bar, tubing, wire

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[a] At 1500 F as cast.

[b] Charpy V-notch.

[c] Izod impact strength on notched or unnotched specimen; actually specimen stops pendulum.

[d] Hardness of electrolytic cobalt is 270-310 Bhn.

Coppers and Plain Brasses—Wrought

Type ➜	Electrolytic Tough Pitch Copper	Deoxidized Copper	Beryllium Copper	Gilding, 95%	Commercial Bronze, 90%
COMPOSITION, %	Cu 99.90 min, O about 0.04	Cu 99.90 min, P 0.015–0.040	Be 1.90–2.15, Co 0.20–0.35, Cu bal	Cu 94.0–96.0, Zn bal	Cu 89.0–91.0, Zn bal
PHYSICAL PROPERTIES					
Density, lb/cu in	0.321–0.323	0.323	0.296–0.298	0.320	0.318
Melting Temp Range, F	1949–1981	1981	1600–1800	1920–1950	1870–1910
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	226	196	100–110[a]	135	109
Coef of Ther Exp (68–572 F), per °F	9.8 x 10^{-6}	9.8 x 10^{-6}	9.3 x 10^{-6}	10.0 x 10^{-6}	10.2 x 10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.092	0.092	0.10[b]	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	1.71	2.03	4.82–5.82[a]	3.1	3.9
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	17 x 10^6	17 x 10^6	19 x 10^6	17 x 10^6	17 x 10^6
Ten Str, 1000 psi[c]					
Annealed	32, 35	32	60–80, 60–80[e]	34	37, 40
Hard	50, 55	50	165–185, 165–185[f]	56	54, 74
Yld Str, 1000 psi[c,d]					
Annealed	10	10	25–35, 20–30[e]	10	10
Hard	45	45	130–150, 150–170[f]	50	54
Elong (in 2 in.), %[c]					
Annealed	45, 35	45	35–50, 35–50[e]	45	45, 50
Hard	6, 1.5	8	3–12, 2–5[f]	5	5, 4
Hardness (Rockwell)					
Annealed	F40	F40	B50–65[e]	F46	F53
Hard	B50	B50	C36–41[f]	B64	B70
Shear Str, 1000 psi[c]					
Annealed	22, 24	22	50–60[e]	26	28, 30
Hard	28, 29	28	90–100[f]	37	38, 42
Endurance Limit (10^8 cycles), 1000 psi[c]					
Annealed	11	—	30–35, 12–20[e,g]	—	10
Hard	13	19	35–40, 120–140[f,g]	—	17, 21
FABRICATING PROPERTIES					
Cold Workability	Excellent	Excellent	Good	Excellent	Excellent
Hot Workability	Excellent	Excellent	Excellent	Good	Good
Hot Working Temp, F	1400–1600	1400–1600	1050–1475	1400–1600	1400–1600
Annealing Temp, F	700–1200	700–1200	1400–1475	800–1450	800–1450
Machinability Index[h]	20	20	20	20	20
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Good	Excellent	Good	Excellent	Excellent
Oxyacetylene Welding	Poor	Fair	Poor	Fair	Good
Carbon Arc Welding	Fair	Good	Excellent	Good	Good
Resistance Welding	Poor	Poor	Excellent	Poor	Poor
CORROSION RESISTANCE	Generally good resistance to industrial, rural and marine atmospheres; also gasolines, fuel oils and lacquers. Generally poor resistance to ammonia, ferric and ammonium compounds, and cyanides. Good resistance to weak acids and bases; some resistance to strong acids and bases				
AVAILABLE FORMS	Flat products, rod, wire, tube, pipe, shapes	Tube, pipe, rod, rolled strip	Flat products, rod, wire, tube, pipe, shapes	Rolled strip	Rolled strip, sheet, wire, tube, plate, rod
USES	Architectural trim; automobile radiators; electrical contacts, conductors and switches; ball floats; rivets; chemical process equipment	Plumbing and gas lines; heat exchanger tubes;air,water, gasoline and oil lines; rotating bands	Instrument and valve springs, plunger guides, bushings, bearings, cams, diaphragms, bellows, electrical contacts, resistance welding electrodes	Coins, bullet jackets, fuse caps, primers, jewelry, base for gold plate or vitreous enamel	Grillwork, cosmetic compacts, marine hardware, primer caps, costume jewelry, vitreous enamel base

[a] Heat treated. [b] 86-212 F. [c] Where two values or ranges appear, second is for wire.
[d] 0.5% extension under load except beryllium copper (0.2% offset). [e] Solution annealed.
[f] Annealed and heat treated 2-3 hr at 600 F. [g] Proportional limit. [h] Based on free-cutting brass = 100.

Plain Brasses—Wrought

Type ➡	Red Brass, 85%	Low Brass, 80%	Cartridge Brass, 70%	Yellow Brass	Muntz Metal
COMPOSITION, %	Cu 84.0–86.0, Zn bal	Cu 78.5–81.5, Zn bal	Cu 68.5–71.5, Zn bal	Cu 63.0–68.5, Zn bal	Cu 59.0–63.0, Zn bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.316	0.313	0.308	0.306	0.303
Melting Temp Range, F	1810–1880	1770–1830	1680–1750	1660–1710	1650–1660
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	92	81	70	67	71
Coef of Ther Exp (68–572 F), per °F	10 4 x 10^{-6}	10.6 x 10^{-6}	11.1 x 10^{-6}	11.3 x 10^{-6}	11.6 x 10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	4.7	5.4	6.2	6.4	6.2
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	17 x 10^6	16 x 10^6	16 x 10^6	15 x 10^6	15 x 10^6
Ten Str, 1000 psi[c]					
Annealed	39, 41	42, 44	44, 48	46, 50	54
Hard	70, 88	74, 107	76	74, 110	—
Yld Str, 1000 psi[c,d]					
Annealed	10	12	11	14	21
Hard	57	59	63	60	—
Elong (in 2 in.), %[c]					
Annealed	48, 48	52, 55	66, 64	65, 60	45
Hard	5, 6	7, 5	8	8, 8	—
Hardness (Rockwell)					
Annealed	F56	F57	F54	F58	F80
Hard	B77	B82	B82	B80	—
Shear Str, 1000 psi[c]					
Annealed	31, 31	32, 32	32, 34	32, 34	40
Hard	42, 48	43, 53	44	43, 55	—
Endur Limit (10^8 cycles), 1000 psi[c]					
Annealed	10.5	14	10	13.5	—
Hard	21, 29	22, 23	21	19, 20	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Excellent	Excellent	Excellent	Fair
Hot Workability	Good	Fair	Fair	Poor	Excellent
Hot Working Temp, F	1450–1650	1500–1650	1350–1550	—	1150–1450
Annealing Temp, F	800–1350	800–1300	800–1400	800–1300	800–1100
Machinability Index[j]	30	30	30	30	40
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Excellent	Good	Good	Good	Good
Oxyacetylene Welding	Good	Good	Good	Good	Good
Resistance Welding	Poor	Poor	Fair	Fair	Fair
CORROSION RESISTANCE	Generally good resistance to industrial, rural and marine atmospheres; also gasolines, fuel oils and lacquers. Generally poor resistance to ammonia, ferric and ammonium compounds, and cyanides				
	Good res to weak acids and bases; some res to strong acids and bases. Highly res to dezincification or stress-corrosion cracking	Susceptible to dezincification and stress corrosion cracking			
		Good res to weak bases; some res to strong bases and weak acids; poor res to strong acids	Some resistance to weak acids and bases; poor resistance to strong acids and bases. Good resistance to sulfides. Poor resistance to soft and high salinity water		
AVAILABLE FORMS	Rolled strip, sheet, wire, tube, pipe	Wire, rolled strip and flat wire	Rolled strip and bar, flat wire, sheet, rod, wire, tube	Rolled strip and flat wire, drawn flat wire, sheet, plate, rod, wire	Rolled strip and bar, sheet, plate, rod, tube
USES	Weatherstrip, electrical sockets, fasteners, heat exchanger tubes, flexible hose, plumbing, jewelry	Ornamental metal work, battery caps, musical instruments, clock dials, pump lines	Automotive radiator cores and tanks, lamp fixtures, fasteners, springs, ammunition components	Grillwork, reflectors, lamp fixtures, fasteners, stencils, plumbing accessories, springs	Architectural trim, large nuts and bolts, condenser plates, hot forgings, valve stems

[c] Where two values appear, second is for wire.

[d] 0.5% extension under load.

[j] Based on free-cutting brass = 100.

Tin and Aluminum Brasses—Wrought

Type ➡	Admiralty	Naval Brass	Leaded Naval Brass	Manganese Bronze (A)	Aluminum Brass
COMPOSITION, %	Cu 70.0–73.0, Sn 0.9–1.2, As, Sb, or P 0.10 max, Zn bal	Cu 59.0–62.0, Sn 0.5–1.0, Zn bal	Cu 59.0–62.0, Pb 1.25–2.25, Sn 0.5–1.0, Zn bal	Cu 57.0–60.0, Fe 0.8–2.0, Sn 0.5–1.5, Mn 0.5 max, Zn bal	Cu 76.0–79.0, Al 1.75–2.5, As, Sb, or P 0.10 max, Zn bal
PHYSICAL PROPERTIES					
Density, lb/cu in	0.308	0.304	0.305	0.302	0.301
Melting Temp Range, F	1650–1720	1630–1650	1630–1650	1590–1630	1710–1780
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	64	67	67	61	58
Coef of Ther Exp (68–572 F), per °F	11.2 x 10^{-6}	11.8 x 10^{-6}	11.8 x 10^{-6}	11.8 x 10^{-6}	10.3 x 10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	6.9	6.6	6.6	7.2	7.5
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	16 x 10^6	15 x 10^6	15 x 10^6	15 x 10^6	16 x 10^6
Ten Str, 1000 psi					
Annealed[b]	53	57	57	65	60
Quarter Hard	—	69	69	77	—
Half Hard	—	75	75	84	—
Yld Str, 1000 psi[b]					
Annealed	22	25	25	30	27
Quarter Hard	—	46	46	45	—
Half Hard	—	53	53	60	—
Elong (in 2 in.), %					
Annealed	65	47	40	33	55
Quarter Hard	—	27	20	23	—
Half Hard	—	20	15	19	—
Hardness (Rockwell)					
Annealed	F75	B55	B55	B65	F77
Quarter Hard	—	B78	B78	B83	—
Half Hard	—	B82	B82	B90	—
Shear Str, 1000 psi					
Annealed	—	40	36	42	—
Quarter Hard	—	43	39	47	—
Half Hard	—	44	40	48	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Fair	Poor	Poor	Excellent
Hot Workability	Fair	Excellent	Good	Excellent	Fair
Annealing Temp, F	800–1100	800–1100	800–1100	800–1100	800–1100
Machinability Index[c]	30	30	70	30	30
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Good
Silver Alloy Brazing	Good	Good	Good	Good	Good
Oxyacetylene Welding	Good	Good	Fair	Good	Good
Resistance Welding	Fair	Fair	Poor	Good	Good
CORROSION RESISTANCE	Good resistance to industrial, rural and marine atmospheres; petroleum products, alcohols, dry gases and sea water. Fairly good resistance to weak bases. Resistance to some weak bases and weak organic acids, but generally poor resistance to most acids and strong bases. Poor resistance to solutions of cyanides and ammonium compounds. Resistant to dezincification (especially Admiralty and Aluminum Brasses)				
AVAILABLE FORMS	Plate, wire, tube	Rolled strip, rolled and drawn bar, plate, rod, tube, shapes	Drawn bar, rod, shapes	Rod, shapes	Tube
USES	Condenser, evaporator and heat exchanger tubes; condenser tube plates; distiller tubes; ferrules	Aircraft turnbuckle barrels, balls, bolts, marine hardware, nuts, propeller shafts, rivets, valve stems, condenser plates, welding rods	Marine hardware, screw machine products, valve stems	Clutch disks, pump rods, shafting, balls, valve stems and bodies, welding rods	Condenser, evaporator and heat exchanger tubes, distiller tubes, ferrules

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[a] Mechanical properties are based on 1-in. dia. Values for Admiralty and Aluminum Brasses apply to tube; other values apply to rod.
[b] 0.5% extension under load.
[c] Based on free-cutting brass = 100.

Nickel Silvers—Wrought

Type ➡	65-18	65-12	65-12 Leaded	65-10	55-18
COMPOSITION, %	Cu 65, Ni 18, Zn 17	Cu 65, Ni 12, Zn 23	Cu 65, Ni 12, Zn 21, Pb 2	Cu 65, Ni 10, Zn 25	Cu 55, Ni 18, Zn 27
PHYSICAL PROPERTIES					
Density (68 F), lb/cu in.	0.316	0.314	0.314	0.313	0.314
Melting Temp Range, F	1960–2030	1830–1900	1830–1900	1800–1870	1830–1930
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	19	23	22	26	17
Coef of Ther Exp (68–572 F), per °F	9.0 x 10^{-6}	9.0 x 10^{-6}	9.0 x 10^{-6}	9.1 x 10^{-6}	9.3 x 10^{-6}
Spec Ht/(68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Cond (68 F), % IACS	6	8	7.5	9	5.5
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	18 x 10^6	18 x 10^6	17 x 10^6	17.5 x 10^6	18 x 10^6
Ten Str, 1000 psi					
Annealed	56–60	52–61	52–55	49–63	60
Half Hard	70–86	73	—	73–85	—
Hard	85–103	85	70–89	86–105	100
Extra Hard	—	93	—	95	108
Yld Str, 1000 psi[a]					
Annealed	25–30	18–28	18–24	18–28	27
Half Hard	60–80	60	—	60	—
Hard	74–90	75	60–79	75	85
Extra Hard	—	79	—	76	90
Elong (in 2 in.), %					
Annealed	56–60	35–48	40	35–50	40
Half Hard	7–20	11	—	7–12	—
Hard	3	4	3–18	4–5	3
Extra Hard	—	2	—	3	2.5
Hardness (Rockwell)					
Annealed	B40–55	B22–55	B27	B22–52	B55
Half Hard	B78–83	B80	—	B80	—
Hard	B87	B89	B80–86	B89	B91
Extra Hard	—	B92	—	B92	B96
Shear Str, 1000 psi					
Annealed	—	41	—	41	—
Half Hard	—	47	—	50	—
Hard	—	52	—	55	—
Extra Hard	—	56	—	59	—
FABRICATING PROPERTIES					
Annealing Temp, F	1100–1500	1100–1500	1100–1500	1100–1500	1100–1500
Hot Workability	Poor	Poor	Poor	Poor	Poor
Cold Workability	Excellent	Excellent	Good	Excellent	Good
Machinability Index[b]	20	20	60	20	30
Joining	Soldering, excellent; silver alloy brazing, good to excellent; carbon arc welding, fair; resistance welding, excellent; oxyacetylene welding, good				
CORROSION RESISTANCE	Attacked rapidly by oxidizing acids. Resistant to sodium and potassium hydroxide but attacked rapidly by ammonium hydroxide and moist ammonia. Good resistance to rural and marine atmospheres and to fresh and salt waters. Subject to stress corrosion				
AVAILABLE FORMS	Sheet; strip; rods, bars, and shapes; wire; spring. Forging, extruding and casting alloys are also available				
USES	Most popular. Hardware, marine and automotive trim, camera parts, lighting fixtures, costume jewelry, screws, springs, slide fasteners	Slide fasteners, nameplates, decorative trim, camera parts	Key blanks, gears, pinions, screw machine parts, watch parts, camera and binocular parts, musical instrument parts	Rivets, screws, slide fasteners, optical parts, hollow ware, nameplates	Excellent for springs. Springs and contacts in telephone equipment, electrical controls. Resistance wire, surgical and dental instruments, diaphragms, hardware

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[a] 0.5% extension under load. [b] Based on free-cutting brass = 100.

Phosphor Bronzes—Wrought

Type ➡	Phosphor Bronze, 5% (Grade A)	Phosphor Bronze, 8% (Grade C)	Phosphor Bronze, 10% (Grade D)	Phosphor Bronze, 1.25% (Grade E)
COMPOSITION, %	Cu 94.0 min, Sn 3.5–5.8, P 0.03–0.35	Cu 90.5 min, Sn 7.0–9.0, P 0.03–0.35	Cu 88.5 min, Sn 9.0–11.0, P 0.03–0.25	Cu 98.5 min, Sn 1.0–1.5, P trace
PHYSICAL PROPERTIES				
Density, lb/cu in	0.320	0.318	0.317	0.321
Melting Temp Range, F	1750–1920	1620–1880	1550–1830	1900–1970
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	47	36	29	120
Coef of Ther Exp (68–572 F), per °F	9.9×10^{-6}	10.1×10^{-6}	10.2×10^{-6}	9.9×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	9.6	13	16	3.6
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	16×10^6	16×10^6	16×10^6	17×10^6
Ten Str, 1000 psi[a]				
Annealed	47, 50	55, 60	66, 66	40, —
Half Hard	68, 85	76, 105	83, 118	55, —
Hard	81, 110	93, 130	100, 147	65, 76
Spring	100, 140	112, —	122, —	75, —
Extra Spring	107, —	120, —	128, —	—, —
Yld Str, 1000 psi[b]				
Annealed	19	24	28	14
Half Hard	55	55	—	—
Hard	75	72	—	50
Elong (in 2 in.), %				
Annealed	64	70	68	48
Half Hard	28	32	32	16
Hard	10	10	13	8
Spring	4	3	4	4
Extra Spring	3	2	3	—
Hardness (Rockwell)				
Annealed	B26	B50	B55	—
Half Hard	B78	B84	B92	B64
Hard	B87	B93	B97	B75
Spring	B95	B98	B101	B79
Extra Spring	B97	B100	B103	—
FABRICATING PROPERTIES				
Cold Workability	Excellent	Good	Good	Excellent
Hot Workability	Poor	Poor	Poor	Good (1450–1600 F)
Annealing Temp, F	900–1250	900–1250	900–1250	900–1200
Machinability Index[c]	20	20	20	20
Joining				
Soft Soldering	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Good	Good	Good	Excellent
Oxyacetylene Welding	Good	Good	Good	Good
Resistance Welding	Good	Excellent	Excellent	Fair
Common Processes	Blanking, drawing, forming and bending, heading and upsetting, roll threading and knurling, shearing, stamping	Blanking, drawing, forming and bending, shearing, stamping	Blanking, forming and bending, shearing	Blanking, forming and bending, heading and upsetting, shearing, squeezing and swaging
CORROSION RESISTANCE	Generally good resistance to atmosphere, water and salt water, and salt solutions. Some resistance to alkaline solutions and inorganic acids. Poor resistance to organic acids, cyanides, and ferric and ammonium compounds			
AVAILABLE FORMS	Rolled strip, rolled flat wire, rod, wire, tube	Rolled strip, rod, wire		Rolled strip, wire
USES	Bridge bearing plates, chemical hardware, perforated sheets, textile machinery, welding rods, beater bars, bellows, clutch disks, cotter pins, diaphragms, fuse clips, fasteners, lock washers, sleeve bushings, springs, switch parts, truss wire, wire brushes		Heavy bars and plates for severe compression, good wear and corrosion resistance. Bridge and expansion plates	Electrical contacts, flexible hose, pole-line hardware

[a] Two values are for flat products and wire, respectively.
[b] 0.5% extension under load.
[c] Based on free-cutting brass = 100.

Cupro-Nickels—Wrought

Type ➜	**Cupro-Nickel, 30%**	**Cupro-Nickel, 20%**	**Cupro-Nickel, 10%**
COMPOSITION, %	Cu 68.9, Ni 30, Fe 0.5, Mn 0.6	Cu bal, Ni 21, Fe 0.5, Mn 0.6	Cu 88.35, Ni 10, Fe 1.25, Mn 0.4
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.323	0.323	0.323
Melting Temp Range, F	2260–2140	2190–2100	2080–2020
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	17	21	26
Coef of Ther Exp (68–572 F), per °F	9.0×10^{-6}	9.1×10^{-6}	9.3×10^{-6}
Specific Heat, Btu/lb/°F	0.09	0.09	0.09
Electrical Resistivity (68 F), microhm-cm	37	27	15
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	22×10^6	20×10^6	18×10^6
Tensile Strength, 1000 psi			
Annealed[a]	$54–60^6$	45–51	44
Half Hard[b]	73	—	—
Hard[b]	80	—	—
Light Drawn[c]	75	80	60
Yield Strength (0.5% ext), 1000 psi			
Annealed[a]	20–22	—	15
Half Hard[b]	68	—	—
Hard[b]	73	—	—
Light Drawn[c]	—	75	57
Elongation (in 2 in.), %			
Annealed[a]	40–45	27	40
Half Hard[b]	12	—	—
Hard[b]	6	—	—
Light Drawn[c]	45	40	42
Hardness (Rockwell)			
Annealed[a]	B37–50	—	B10
Half Hard[b]	B80	—	—
Hard[b]	B85	—	—
Light Drawn[c]	B85	B81	B72
Creep Strength (0.001%/1000 hr), 1000 psi			
At 300 F	24	>25	>30
At 500 F	16	17	11
FABRICATING PROPERTIES			
Cold Workability	Good	Good	Good
Hot Workability	Good	Good	Good
Hot Working Temp, F	1700–1900	1650–1850	1550–1750
Annealing Temp, F	1200–1500	1200–1500	1100–1500
Machinability Index[d]	20	20	20
Joining			
Soft Soldering	Excellent	Excellent	Excellent
Silver Alloy Brazing	Excellent	Excellent	Excellent
Metal Arc Welding	Excellent	Excellent	Good
Gas Shielded Arc Welding	Excellent	Excellent	Excellent
Resistance Welding	Excellent	Excellent	Good
Oxyacetylene Welding	Fair	Fair	Fair
Carbon Arc Welding	Not recommended	Not recommended	Not recommended
CORROSION RESISTANCE	Resistant to attack by high velocity sea water, fresh water, steam; sulfuric, phosphoric and mild organic acids; ammonia and ammoniacal compounds, chlorides, sulfates, nitrates		
AVAILABLE FORMS	Plate, rod, strip, tube, wire		
USES	Condenser tubes and plates, heat exchanger tubes, salt water piping, evaporator tubes, process equipment, distillation tubes. ASME code permits use of Cupro-Nickel, 30% in heat exchangers and unfired pressure vessels up to 700 F		

[a] Properties of annealed materials vary with grain size. [b] Strip. [c] Tube. [d] Based on free-cutting brass = 100.

Leaded Brasses and Bronzes—Cast

BBII Grade ➡	Leaded Tin Bronzes[a]		
	2A	2B	2C
COMPOSITION, %	Cu 88, Sn 6, Pb 1.5, Zn 4.5	Cu 87, Sn 8, Pb 1, Zn 4	Cu 87, Sn 8, Pb 1, Zn 2
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.311–0.318	0.314–0.320	0.314–0.320
Melting Temp Range, F	1830	1830–1570	1830–1570
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	28	28
Coef of Ther Exp (70–350 F), per °F	10.3 x 10^{-6}	10 x 10^{-6}	10 x 10^{-6}
Electrical Conductivity (68 F), % IACS	14	11	11
MECHANICAL PROPERTIES[b]			
Mod of Elast in Tension, psi	12–16 x 10^6	10.6–16 x 10^6	10.6–16 x 10^6
Tensile Strength, 1000 psi	36–48	33–43	36–46
Yield Strength (0.5% ext), 1000 psi	16–21	16–24	18–26
Elongation (in 2 in.), %	25–40	18–30	15–25
Reduction of Area, %	16–33	15–30	12–26
Hardness (Brinell)	60–72	60–75	65–80
Impact Strength (Izod), ft-lb	11–16	12–15	7–10
Compr Yld Str (0.001-in. set), 1000 psi	12–15	9–11	12–14
FABRICATING PROPERTIES			
Casting Temp Range, F			
Light Castings	2000–2300	2100–2300	1200–2300
Heavy Castings	1900–2150	1920–2100	1920–2100
USES	Oil pumps, gears, bushings, high duty bearings, ornamental bronze	General utility structural bronze, pipe fittings, expansion joints, pressure valves	Bolts, nuts, gears, valves, pump pistons, pressure pipe fittings, expansion joints

BBII Grade ➡	High-Leaded Tin Bronzes[a]			
	3A	3B	3D	3E
COMPOSITION, %	Cu 80, Sn 10, Pb 10	Cu 83, Sn 7, Pb 7, Zn 3	Cu 78, Sn 7, Pb 15	Cu 71, Sn 5, Pb 24
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.321–0.328	0.320–0.322	0.329–0.340	0.332–0.343
Melting Temp (approx), F	1770	1800	1750	1700
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	27	—	—	—
Coef of Ther Exp (70–400 F), per °F	10.2 x 10^{-6}	10 x 10^{-6}	10.3 x 10^{-6}	—
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension	8.5–13 x 10^6	—	8.8–12.6 x 10^6	9–12 x 10^6
Tensile Strength, 1000 psi	27–37	30–38	25–33	23–30
Yield Strength (0.5% ext), 1000 psi	15–22	17–21	14–20	11–15
Elongation (in 2 in.), %	8–12	12–20	10–18	7–16
Reduction of Area, %	5–11	10–22	8–15	5–12
Hardness (Brinell)	55–70	55–65	50–60	42–35
Impact Strength (Izod), ft-lb	2–8	—	4–6	4–6
Compr Yld Str (0.001-in. set), 1000 psi	12.5–16	—	13–16	12–14
FABRICATING PROPERTIES				
Casting Temp Range, F				
Light Castings	2000–2250	2000–2250	2000–2250	2000–2200
Heavy Castings	1850–2100	1900–2050	1900–2100	1850–2000
USES	General purpose bushing and bearing alloy	General purpose bearing alloy, bushings, automobile fittings	Bearing bronze for moderate pressure, mine water pump parts	Bearings operating at high speed and light or medium pressure

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[a] Corrosion resistance generally the same as for nonleaded alloys of similar composition.
[b] Values are given for the as-cast condition.

Leaded Brasses and Bronzes—Cast

BBII Grade ➔	Leaded Red Brass[a]		Leaded Semi-Red Brass[a]	
	4A	4B	5A	5B
NOMINAL COMPOSITION, %	Cu 85, Sn 5, Pb 5, Zn 5	Cu 83, Sn 4, Pb 6, Zn 7	Cu 81, Sn 3, Pb 7, Zn 9	Cu 76, Sn 3, Pb 6, Zn 15
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.314–0.321	0.311–0.314	0.311–0.318	0.309–0.314
Melting Temp Range, F	1840–1550	1800	1800	1775
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	36	—	—	—
Coef of Ther Exp (70–400 F), per °F	10.9 x 10^{-6}	—	—	—
Elec Cond (68 F), % IACS	15	—	18	—
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi	9.1–14.8 x 10^6	—	7.7–14.3 x 10^6	10–14 x 10^6
Ten Str, 1000 psi	33–46	30–38	29–39	30–40
Yld Str (0.5% ext), 1000 psi	17–24	12–17	13–17	12–16
Elongation (in 2 in.), %	20–35	15–27	18–30	20–35
Red. of Area, %	17–32	12–25	15–27	15–30
Hardness (Brinell)	55–65	50–60	50–60	50–60
Impact Str (Izod), ft-lb	6–12	—	6–10	—
Compr Yld Str (0.001-in. set), 1000 psi	10–12	11–12	—	8–10
FABRICATING PROPERTIES				
Casting Temp Range, F				
Light Castings	2100–2350	2100–2300	2100–2300	2100–2300
Heavy Castings	1950–2150	1950–2150	1950–2150	1950–2150
USES	Low pressure valve bodies, pipe fittings, pump impellers, plumbing goods	Air, gas and water fittings, valves, pump parts, hardware, carburetors	Low pressure valves and fittings, hardware, plumbing fittings	Plumbing fixtures, air and gas fittings, hardware, low pressure valves and fittings

BBII Grade ➔	Leaded Nickel Brass and Bronze[a]			
	10A	10B	11A	11B
COMPOSITION, %	Cu 57, Sn 2, Pb 9, Zn 20, Ni 12	Cu 60, Sn 3, Pb 5, Zn 16, Ni 16	Cu 64, Sn 4, Pb 4, Zn 8, Ni 20	Cu 66.5, Sn 5, Pb 1.5, Zn 2, Ni 25
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.318–0.322	0.318–0.322	0.318–0.322	0.318–0.322
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	16	16	14	15
Elec Cond (68 F), % IACS	5–7	5–6	4.5–5.5	4–5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	15–16.5 x 10^6	—	17–18 x 10^6	19–22 x 10^6
Ten Str, 1000 psi	30–40	35–45	40–60	50–65
Yld Str (0.5% extn), 1000 psi	15–20	17–24	17–30	26–40
Elongation (in 2 in.), %	10–25	15–30	15–25	15–25
Red. of Area, %	7–20	15–30	11–22	15–30
Hardness (Brinell)	50–60	65–80	76–120	120–150
FABRICATING PROPERTIES				
Casting Temp Range, F				
Light Castings	2200–2400	2250–2450	2300–2600	2400–2600
Heavy Castings	2000–2200	2050–2250	2250–2400	2300–2400
USES	Hardware fittings, valves and trim, plumbing fittings	Valves and fittings, boat and railroad car fittings, pipe fittings	Marine fittings, furniture trim, building trim, valves, hardware	Dairy and soda fountain parts, valves and seats for elevated temp

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[a] Corrosion resistance generally the same as for nonleaded alloys of similar composition.

[b] Values are given for the as-cast condition.

continued on next page

Brasses and Bronzes—Cast

BBII Grade ➜	High Strength Yellow Brass[a]		
	7A	8A	8C
COMPOSITION, %	Cu 56–62, Sn 0.5–1, Pb 0.5–1, Fe 0.75–1.5, Al 0.25–1, Mn 0.1–0.5, Zn bal	Cu 56–59, Sn 1 max, Pb 0.3 max, Fe 0.75–2, Al 0.75–1.5, Mn 0.1–1, Zn bal	Cu 60–68, Pb 0.1 max, Fe 2–4, Al 4–7.5, Mn 3–4.5, Zn bal
PHYSICAL PROPERTIES			
Density, lb/cu in	0.289–0.303	0.289–0.307	0.278–0.289
Melting Temp Range, F	1675–1725	1660–1700	1650–1700
Coef of Ther Exp (70–400 F), per °F	11.4×10^{-6}	12×10^{-6}	11×10^{-6}
Electrical Conductivity (68 F), % IACS	20–24	16–20	10–14
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$12–14 \times 10^{6}$	$13–15 \times 10^{6}$	$15–16.5 \times 10^{6}$
Tensile Strength, 1000 psi	60–78	70–88	110–120
Yield Strength (0.5% ext), 1000 psi	25–40	28–40	65–90
Elongation (in 2 in.), %	15–30	20–35	12–18
Red. of Area, %	15–30	20–40	5–18
Hardness (Brinell)	80–95	90–120	170–225
Impact Strength (Izod), ft-lb	20–40	20–40	7–12
Compr Yld Str (0.001-in. set), 1000 psi	20–26	22–26	55–65
FABRICATING PROPERTIES			
Casting Temp Range, F			
Light Castings	1900–2050	1900–2000	1950–2150
Heavy Castings	1750–1900	1750–1900	1800–1950
USES	Valve stems, marine castings, pump bodies, gears, brackets	Propeller hubs and blades, valve stems, machine parts, gears	Spur gears, cams, bridge parts, screw down nuts, bearings

BBII Grade ➜	Leaded Yellow Brass[a]		
	6A	6B	6C
COMPOSITION, %	Cu 71, Zn 25, Pb 3, Sn 1	Cu 67, Zn 29, Pb 3, Sn 1	Cu 60, Zn 37.75, Pb 1, Sn 1, Al 0.25
PHYSICAL PROPERTIES			
Density, lb/cu in	0.305–0.309	0.303–0.307	0.300–0.360
Melting Temp Range, F	1700–1750	1700–1725	1675–1725
Coef of Ther Exp (70–200 F), per °F	11.5×10^{-6}	11.2×10^{-6}	12×10^{-6}
Electrical Conductivity (68 F), % IACS	15–22	18–25	20–26
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$11–14 \times 10^{6}$	$12–14 \times 10^{6}$	$13–15 \times 10^{6}$
Tensile Strength, 1000 psi	35–40	30–38	40–45
Yield Strength (0.5% ext), 1000 psi	12–14	11–15	14–20
Elongation (in 2 in.), %	25–40	20–35	15–25
Red. of Area, %	20–40	15–30	18–30
Hardness (Brinell)	40–55	40–60	50–75
Compr Yld Str (0.001-in. set), 1000 psi	8–10	8–10	—
FABRICATING PROPERTIES			
Casting Temp Range, F			
Light Castings	2000–2100	1950–2100	1950–2150
Heavy Castings	1850–2000	1850–1950	1800–2000
USES	Plumber's fittings and fixtures, ferrules, hardware, andirons	Valves and fittings, spray nozzles, battery clamps, ship fittings	Ship fittings, plumber's flanges, hardware, Navy yellow brass

[a] Corrosion resistance generally the same as for nonleaded alloys of similar composition.

Aluminum Bronzes—Cast

BBII Grade ➡	9A	9B	9C	9D
COMPOSITION, %	Cu 87.5, Al 9, Fe 3.5	Cu 89, Al 10, Fe 1	Cu 83 min, Al 10–11.5, Fe 3–5, Ni 2.5 max, Mn 0.5 max	Cu 81, Al 11, Fe 4, Ni 4
PHYSICAL PROPERTIES				
Density, lb/cu in	0.267	0.270	0.272	0.273
Melting Point Range, F	—	1900	1910–1850	1937
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	33	—	22
Coef of Ther Exp, per °F	9.5×10^{-6}[a]	9.5×10^{-6}[b]	9.0×10^{-6}[b]	—
Elec Res (68 F), microhm-cm	13	13.5	12	7.5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	17×10^6	15×10^6	18×10^6	17×10^6
Ten Str, 1000 psi				
Sand Cast	75	67	75	95
Sand Cast & Heat Treated	—	90[c]	105[d]	115[e]
Yld Str (0.5% ext), 1000 psi				
Sand Cast	27	32	35	45
Sand Cast & Heat Treated	—	40[c]	52[d]	70[e]
Elongation (in 2 in.), %				
Sand Cast	35	15	18	7
Sand Cast & Heat Treated	—	15[c]	10[d]	5[e]
Hardness (Brinell)				
Sand Cast	120	140	155	195
Sand Cast & Heat Treated	—	180[c]	230[d]	235[e]
THERMAL TREATMENT				
Normalizing Temp, F	Heat to 1500, furnace cool to 1000, air cool			
Quenching Temp, F	1600–1700	1600–1700	1600–1700	1600–1700
Tempering Temp, F	700–1200	700–1200	700–1200	700–1200
FABRICATING PROPERTIES				
Castability	Because of narrow freezing ranges and high shrinkage, aluminum bronzes are difficult to cast. In addition, they are sensitive to gases. In melting, precautions must be taken to minimize stirring and breaking the oxide skin on the surface of the melt to prevent absorption of gases. In pouring, agitation must be avoided, and castings are generally bottom gated to reduce turbulence. Shrinkage difficulties are overcome by use of large risers (to feed the casting) and chills			
Machinability Index (free-cutting brass = 100)	20–30	20–30	20–30	20–30
Weldability	Can be welded by carbon arc, inert-gas arc and resistance methods. Can be brazed with silver brazing alloys, but require special fluxes			
CORROSION RESISTANCE	Generally good resistance to atmosphere, water and salt water, and salt solutions. Some resistance to alkaline solutions and nonoxidizing inorganic acids. Poor resistance to ammonia compounds, ferric salts and oxidizing inorganic acids			
USES	Machine parts, pump impellers and castings, gears, rolling mill bearings, segments and washers, bearings, chemical plant equipment, pickling equipment such as chains and hooks, marine propellers, pump casings, fittings			

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[a] 70-250 F. [b] 70-500F.

[c] Water quenched from 1625 F, tempered at 1125 F, water quenched.

[d] Water quenched from 1625 F, tempered at 1000 F, water quenched.

[e] Water quenched from 1625 F, tempered at 1150 F, water quenched.

Lead and Its Alloys—Cast, Wrought[a]

Type ➜	Chemical Lead	Common Lead (soft lead)	Tellurium Lead
COMPOSITION, %	Pb 99.90+	Pb 99.73+	Te 0.05, Cu 0.06 max
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.41	0.41	0.41
Melting Point, F	618	621	617
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	19.6	19.6	19.3
Coef of Ther Exp, per °F	16.3×10^{-6}	16.3×10^{-6}	16×10^{-6}
Specific Heat (32 F), Btu/lb/°F	0.031	0.031	0.031
Electrical Resistivity (68 F), microhm-cm	—	20.6	—
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	2×10^{6}	2×10^{6}	1.5×10^{6}
Tensile Strength, psi			
Rolled	2450	2090	—
Extruded	2200	2000	—
Sand Cast	—	1800	—
Chill Cast	2200	2000	—
Yield Strength, psi			
Rolled	1640	—	—
Extruded	—	—	1500
Sand Cast	—	800	—
Elongation (in 2 in.), %			
Rolled	57	43	40
Extruded	48	—	—
Sand Cast	—	30	—
Chill Cast	40	47	—
Reduction of Area, %			
Sand Cast	—	100	—
Chill Cast	—	100	—
Hardness (Brinell)			
Extruded	—	—	6
Sand Cast	—	3.2–4.5	—
Chill Cast	—	4.2	—
Impact Strength (Charpy, chill cast), ft-lb	—	10	—
Endurance Limit (10^7 cycles), psi			
Extruded & Aged	725	470	1000
Sand Cast	—	470	—
Shear Strength, psi			
Sand Cast	—	1820	—
Chill Cast	—	1820	—
Creep Strength (0.1% per yr, rolled, 85 F), psi	300	250	300
FABRICATING PROPERTIES	Formed by cold rolling and extrusion		
Casting Temp Range, F	790–850	790–850	790–850
Joining	Soft solder with 50-50 or 40-60 solder using rosin or stearic acid flux. Oxyhydrogen welding (lead burning); slightly reducing flame; no flux		
CORROSION RESISTANCE	Resistant to sulfuric, sulfurous, phosphoric and chromic acids. Attacked by acetic, formic and nitric acids. Resistant to atmosphere and fresh and salt water		
AVAILABLE FORMS	Castings, rolled and extruded shapes, sheet		
USES	Chemical apparatus	Storage batteries, cable sheath, ammunition, calking. alloying, coatings, liquid baths for heat treating	Chemical apparatus

*See also Tin-Lead-Antimony Alloys.

Lead and Its Alloys—Wrought

Type ➡	1% Sb-Lead	Hard Lead	Hard Lead	8% Sb-Lead	Grid Metal (7-12% Sb)
COMPOSITION, %	Sb 1	Sb 4	Sb 6	Sb 8	Sb 9
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.406	0.398	0.393	0.388	0.385
Melting Temp Range, F	608–595	570–486	545–486	520–486	509–486
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	19	18	17	16	16
Coef of Ther Exp (68–212 F), per °F	16×10^{-6}	15.5×10^{-6}	15.4×10^{-6}	14.5×10^{-6}	14.4×10^{-6}
Spec Ht, Btu/lb/°F	0.031	0.032	0.032	0.032	0.032
Elec Res (68 F), microhm-cm	22	24	25	26.5	27.1
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	2×10^{6}	—	—	—	—
Ten Str, 1000 psi					
Rolled	3.0	4.0	4.1	4.6	4.7
Extruded	2.9	3.1	3.3	3.3	—
Extruded & Aged	3.0	—	—	—	—
Chill Cast	3.4	5.6	6.8	7.4	7.4
Elong (in 2 in.), %					
Rolled	60	48	47	31	17
Extruded	58	58	65	75	—
Extruded & Aged	50	—	—	—	75
Chill Cast	16	22	24	19	—
Hardness (Brinell)					
Rolled	5.9	8	—	9.5	7.8
Extruded	5.1	8.9	10.7	12.4	—
Extruded & Aged	7	—	—	—	—
Chill Cast	7	10	11.8	13.3	15.4
Endurance Limit, psi[a]					
Rolled	—	1500	1500	1750	—
Extruded	—	—	1200	—	—
Extruded & Aged	1150	—	—	—	—
Chill Cast	—	—	2500	—	2700
Creep Str (86 F)[b]					
Rolled	—	250	400	425	400
Extruded	350	210	—	—	—
FABRICATING PROPERTIES					
Casting Temp Range, F	750–925	750–925	750–850	750–925	750–925
Joining	Soft solder with 50–50 or 40–60 solder using rosin or stearic acid flux. Oxyhydrogen welding (lead burning): no flux, slightly reducing flame				
CORROSION RESISTANCE	Similar to soft lead (see opposite page)				
USES	Cable sheathing	Rolled sheet for roofing and flashing; extruded pipe for corrosion resistance applications requiring greater strength than soft lead			Battery grids

[a] 2×10^{7} cycles.
[b] 1% extension in 10,000 hr.

Magnesium Alloys—Wrought

ASTM Type ➡	M1A	AZ31B-F	AZ61A-F	AZ80A-F
COMPOSITION, %	Mn 1.20 min	Al 2.5–3.5, Zn 0.6–1.4, Mn 0.20 min	Al 5.8–7.2, Zn 0.4–1.5, Mn 0.15 min	Al 7.8–9.2, Zn 0.2–0.8, Mn 0.12 min
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.063	0.064	0.065	0.066
Melting Temp Range, F	1200	1050–1170	950–1140	900–1115
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	79.9	43.6	33.8	29.0
Coef of Ther Exp, per °F				
65 to 212 F	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}
65 to 750 F	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}
Spec Ht (78 F), Btu/lb/°F	0.25	0.25	0.25	0.25
Elec Res (68 F), microhm-cm[b]	5.0	9.2	12.5	14.5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Ten Str, 1000 psi				
Extruded[b]	26–38	35-39	40-45	40-49[a]
Forged	36	—	43	46[a]
Yld Str, 1000 psi				
Extruded[b]	23–28	23–28	22-32	23-35[a]
Forged	23	—	26	31[a]
Elong (in 2 in.), %				
Extruded	8–11	12–18	15-16	10-12
Forged	7	—	12	8
Compr Yld Str, 1000 psi				
Extruded[b]	10–13	15-17	15-21	21-26[a]
Forged	—	—	18	25[a]
Hardness (Brinell)				
Extruded[b]	42-46	49-50	55-60	60-67
Forged	47	—	55	69
Shear Str, 1000 psi				
Extruded	16	19	21	21
Forged	16	—	21	22
Endurance Limit, 1000 psi				
Extruded	9	14	17	19
Forged	—	—	16	18
Impact Str (Charpy), ft-lb				
Extruded	2.1	3.2	3	2.2
Forged	—	—	2.2	1.8
THERMAL TREATMENT				
Annealing Temp, F	700	650	650	725
Stress Relief Temp, F[d]	500	500	500	400
Solution Temp, F	—	—	—	750
Aging Temp, F	—	—	—	350
FABRICATING PROPERTIES				
Hot Working Temp Range, F[c]	550-650	450-650	450-650	275-375
Weldability[e]				
Torch	A	B	C	D
Inert-Gas Arc	A	A	A	C
Elec Res	A	A	A	A
Machinability Index (free-cutting brass = 100)	500	500	500	500
Hot Formability[e]	A	A	B	C
Cold Formability	B	A	C	D
CORROSION RESISTANCE	High resistance to atmosphere			
AVAILABLE FORMS	Sheet, plate, rod, bar, extruded shapes, tubing, forgings		Rod, bar, extruded shapes, tubing, forgings	
APPLICATIONS	Airframe parts, textile machinery, truck bodies, jet engine parts			

[a] Tensile, tensile yield and compressive yield strengths, and hardness of AZ80A-F can be increased several per cent by heat treating, at some expense to elongation.

[b] Generally, strengths and hardness of extruded bar are highest, extruded tubing lowest, and extruded shapes intermediate in the ranges of values given.

[c] Higher working temperatures can be used if they do not require heating hard rolled or aged alloys above the annealing or aging temperature.

[d] For extrusions. [e] Letter A indicates most favorable, B less favorable, etc. Relative to magnesium alloys only.

Magnesium Alloys—Wrought

ASTM Type➜	HM31X[a]	HM21A-T8[c]	HK31A	—	—	ZK60A-F
COMPOSITION, %	Th 2.5-3.5, Mn 1.2 min	Th 1.5-2.5, Mn 0.35-0.8	Zr 0.4-1, Th 2.5-4	Zn 0.75-1.5, Zr 0.5-1.0	Zn 2.5-4, Zr 0.5-1.0	Zn 4.8-6.2, Zr >0.45
PHYSICAL PROPERTIES						
Density, lb/cu in.	0.0651	0.0640	0.0647	0.064	0.065	0.0659
Melting Temp Range, F	1202-1121	1202-1121	1202-1092	—	—	1175-968
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	60	80	66	73	73	67
Coef of Ther Exp (68-400 F), per °F	10.5×10^{-6}	14.5×10^{-6}	14.5×10^{-6}	15.1×10^{-6}	15.1×10^{-6}	14.5×10^{-6}
Spec Ht, Btu/lb/°F	0.245	0.245	0.245	0.245	0.245	0.245
Elec Res (68 F), microhm-cm	6.6	5.1	6.4	5.8	5.8	6.0
MECHANICAL PROPERTIES[d]						
Mod of Elast in Tension, psi	6.5×10^{6}	6.5×10^{6}	6.5×10^{6}	6.5×10^{6}	6.5×10^{6}	6.5×10^{6}
Ten Str, 1000 psi	—, —, 37	34, 33, —	37[c], —, —	36-45, —, 15-20	40-45, 45-49, 47-51	—, 49, 49[a]-52[b]
Yld Str (0.1% set), 1000 psi	—, —, 26	25, 20, —	29, —, —	24-27, —, 27-32	27-31, 31-33, 33-38	—, 38, 37[a]-42[b]
Elong (in 2 in.), %	—, —, 10	10, 15, —	8, —, —	8-18, —, —	8-18, 12-14, 15-25	—, 13, 13[a]-12[b]
Hardness (Vickers)	—, —, —	—, —, —	55, —, 55	55-75, —, 60-80	60-80, 60-80, 60-80	—, 75, 75
Impact Str (Izod), ft-lb	—, —, —	—, —, —	—, —, —	—, —, —	—, 3-5, 7-9	—, —, —
Fatigue Str, 1000 psi	—, —, —	—, —, —	—, —, —	—, —, 16.8	—, —, 19	—, —, —
Compr Yld Str, 1000 psi	—, —, 15	15, 17, —	23, —, —	—, —, 22-29	—, 20-29, 27-33	—, 28, 25-33
Creep Str (stress to give 0.5% ext in 100 hr), 1000 psi						
400 F	—	13.5	11	—	—	—
500 F	—	9.0	2.0	—	—	—
600 F	—	6.0	—	—	—	—
THERMAL TREATMENT						
Aging Temp, F	—	—	—	—	—	275 (48 hr)
FABRICATING PROPERTIES						
Hot Working Temp, F	650-800	650-800	650-700	500	500	300-500
Machinability (free-cutting brass = 100)	500	500	500	500	500	500
Weldability	Can be welded by inert-gas shielded arc methods and spot welding					Not weldable
CORROSION RESISTANCE	Good resistance to the atmosphere; attacked by salt water					
AVAILABLE FORMS	Extrusions	Sheet, plate, forgings	Sheet, plate	Sheet, extrusions, tubing	Sheet, forgings, extrusions	Extrusions, forgings
USES	High temp (600-850 F) aircraft service, missile components	High temp (600-900 F) aircraft service, missile components	High temp (600-800 F) aircraft service, missile components	Airframe parts, skins, ribs and spars, windows		

[a] As extruded. [b] Heat treated. [c] T8 temper for sheet, T5 temper for forgings.
[d] Mechanical properties given for sheet, forgings and extrusions, in that order.

Magnesium Alloys—Cast

Type[a] →	AZ63A	M1B	AZ92A	AM100A	AZ91A
COMPOSITION, %	Al 5.3–6.7, Zn 2.5–3.5, Mn 0.15 min	Mn 1.20 min	Al 8.3–9.7, Zn 1.6–2.4, Mn 0.10 min	Al 9.3–10.7, Zn 0.3 max, Mn 0.10 min	Al 8.3–9.7, Zn 0.4–1.0, Mn 0.13, min
PHYSICAL PROPERTIES					
Density, lb/cu in	0.067	0.064	0.066	0.066	0.066
Melting Temp Range, F	850–1135	1200	830–1100	865–1100	875–1105
Ther Cond (212–572 F), Btu/hr/sq ft/°F/ft	29.0–38.7	—	26.6–33.8	24.2–36.3	26.6–31.5
Coef of Ther Exp (66–212 F), per °F	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}
Spec Ht (78 F), Btu/lb/°F	0.25	0.25	0.25	0.25	0.25
Elec Res, microhm-cm					
As Cast	11.0	6.6	12.4	11.4	12.9
Solution Treated	14.0	—	16.8	17.2	16.2
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Ten Str, 1000 psi					
As Cast	29	14	24	22	36
Sol'n Treated	40	—	40	40	—
Sol'n Treated & Aged	40	—	40	40	—
Yield Str, 1000 psi					
As Cast	14	4.5	14	12	23
Sol'n Treated	14	—	14	13	—
Sol'n Treated & Aged	19	—	22	19	—
Elongation (in 2 in.), %					
As Cast	6	5	2	2	4
Sol'n Treated	12	—	10	10	—
Sol'n Treated & Aged	5	—	2	1	—
Hardness (Brinell)					
As Cast	50	33	65	53	60
Sol'n Treated	55	—	63	52	—
Sol'n Treated & Aged	73	—	83	69	—
Shear Str, 1000 psi					
As Cast	18	11	19	18	20
Sol'n Treated	19	—	20	20	—
Sol'n Treated & Aged	21	—	21	22	—
Endurance Limit, 1000 psi					
As Cast	11	—	11	10	14
Sol'n Treated	14	—	14	11	—
Sol'n Treated & Aged	13	—	13	10	—
Impact Str (Izod), ft-lb					
As Cast	3	9	1	2	2
Sol'n Treated	5	—	4	4	—
Sol'n Treated & Aged	2	—	1	2	—
THERMAL TREATMENT					
Solution Temp, F	730	—	760	790	—
Aging Temp, F	375	—	420	400	—
Stabilizing Temp, F	500	—	500	500	—
FABRICATING PROPERTIES					
Casting Temp, F					
Sand	1350–1550	1350–1550	1350–1550	1350–1550	—
Chill	1200–1500	—	1200–1500	1200–1500	1150–1250
Weldability[b,c]	D, D, A	A, A, A	D, A, A	D, A, A	—
Machinability Index[d]	500	500	500	500	500
CORROSION RESISTANCE					
Resistance to Atmosphere	Good	Good	Good	Good	Good
Resistance to Salt Water[b]	B	A	B	D	B
AVAILABLE FORMS	Sand castings	Sand castings	Sand and perm mold castings	Sand and perm mold castings	Die castings
USES	Parts for aircraft landing wheels and reciprocating and jet type engines. Vacuum cleaners, portable grinders and drills, foundry flasks, textile machinery, pistons. Various fittings				

[a] ASTM B80-55T, B199-55T and B94-54.

[b] Letter A indiates most favorable, B less favorable, etc. Relative to magnesium alloys only.

[c] Ratings for torch, inert-arc and electrical resistance methods in that order.

[d] Based on free-cutting brass = 100.

Magnesium Alloys—Cast

ASTM Type[a] →	EZ33A	HZ32A	ZH62A	ZK51A
COMPOSITION, %	Zn 2.0-3.5, Zr 0.5 max, rare earths 2.5-4	Zn 1.7-2.5, Zr 0.5 min, Th 2.5-4	Zn 4.8-6.2, Zr 0.5 min, Th 1.4-2.2	Zn 3.5-5.5, Zr 0.5-1
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.0659	0.0659	0.0670	—
Melting Temp Range, F	1189-1010	1198-1026	1165-960	1185-1020
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	58	60	65	65
Coef of Ther Exp (68-400 F), per °F	14.9×10^{-6}	14.8×10^{-6}	14.8×10^{-6}	15.2×10^{-6}
Spec Ht, Btu/lb/°F	0.245	0.245	0.245	—
Elec Res (68 F), microhm-cm	7.0	6.5	6.6	6.6
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Ten Str, 1000 psi	23	30	40	38
Yld Str, 1000 psi	15[b]	14[b]	25[c]	23.5[c]
Elong (in 2 in.), %	3	7	6	12
Hardness (Brinell)	50	57	70	75
Impact Str (Izod), ft-lb	1.5	2	1.5	3
Fatigue Str, 1000 psi[d]	8.3	10.5	11.8	12.3
Compr Yld Str (0.2% set), 1000 psi	10-15	10-14	25	24.5
Creep Str (stress for 0.5% ext in 1000 hr), 1000 psi				
400 F	8.4-10.1	8.7-11.5	—	—
500 F	—	7.4-9.8	—	—
600 F	1.4- 2.1	3.9-6.4	—	—
THERMAL TREATMENT				
Aging Temp, F	350 (16 hr)	600 (16 hr)	625 (2 hr) + 355 (16 hr)	360 (12 hr)
FABRICATING PROPERTIES				
Casting Temp Range, F	1380-1525	—	—	—
Machinability	All of these alloys have excellent machining properties			
Weldability	Can be welded by inert-gas shielded arc methods			
CORROSION RESISTANCE	Good resistance to the atmosphere; attacked by salt water			
USES	Pressure-tight castings; aircraft engine parts, expansion chambers, other parts for service at 300-500 F	Jet engine parts for service to 660 F	Structural castings for service to 400 F; engine parts, airframe parts	Structural castings for service to 300 F; engine parts, gear casings

[a] Mechanical properties given for sand castings. [b] 0.2% set. [c] 0.1% set. [d] 50×10^6 reversals in Wohler type test.

Nickel and Its Alloys—Wrought

Type ➜	A Nickel	Low Carbon Nickel	Duranickel
COMPOSITION, %	Ni 99.45, C 0.06, Mn 0.25, Fe 0.15, S 0.005, Si 0.05, Cu 0.05	Ni 99.55, C 0.01, Mn 0.20, Fe 0.15, S 0.005, Si 0.05, Cu 0.05	Ni 93.90, C 0.15, Mn 0.25, Fe 0.15, S 0.005, Si 0.55, Cu 0.05, Al 4.05, Ti 0.45
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.321	0.321	0.298
Melting Temp Range, F	2615–2635	2615–2635	2550–2620
Ther Cond (80–212F), Btu/hr/sq ft/°F/ft	36	36	10.7 (soft), 11.2 (age hardened)
Coef of Ther Exp (80–212 F), per °F	7.4 x 10^{-6}	7.4 x 10^{-6}	7.2 x 10^{-6}
Specific Heat (80–212 F), Btu/lb/°F	0.130	0.130	0.104
Electrical Resistivity (32 F), microhm-cm	9.5	9.5	46.5 (soft)
Magnetic Transformation Temp, F	680	680	120 (soft)
Magnetic?	Yes	Yes	Yes
MECHANICAL PROPERTIES[a]			
Modulus of Elasticity in Tension, psi	30 x 10^6	30 x 10^6	30 x 10^6
Tensile Strength, 1000 psi			
Annealed	55–75	50–60	90–120
Annealed, Age Hardened	—	—	160–190
Spring	90–130	—	155–190
Spring, Age Hardened	—	—	180–230
Yield Strength, 1000 psi			
Annealed	15–30	12–25	35–60
Annealed, Age Hardened	—	—	—
Spring	70–115	—	—
Spring, Age Hardened	—	—	—
Elongation (in 2 in.) %			
Annealed	55–40	60–40	50–130
Annealed, Age Hardened	—	—	25–10
Spring	15–2	—	10–2
Spring, Age Hardened	—	—	15–5
Hardness (Rockwell)			
Annealed	B64 (max)	B55 (max)	B90 (max)
Annealed, Age Hardened	—	—	C30–40
Spring	B95 (min)	—	C30–40
Spring, Age Hardened	—	—	C36–46
Endurance Limit (10^8 cycles), 1000 psi			
Hot Rolled	33	33	51
Hot Rolled, Age Hardened	—	—	52.5
Cold Drawn	50	50	51
Cold Drawn, Age Hardened	—	—	61
THERMAL TREATMENTS			
Annealing Temperature, F	1500 (2–5 min)	1500 (3–6 min)	1600 (2–5 min)
Aging Temperature, F	—	—	1100 (8–16 hr)
FABRICATING PROPERTIES			
Hot Working Temp Range, F			
Heavy Forging, Drop Forging	1600–2300	1400–2300	1900–2300
Light Forging	1200–1600	1200–1600	1600–1900
Joining	Metallic arc, inert-gas metal arc, oxyacetylene and resistance welding; silver and copper brazing; soft soldering		Metallic arc, inert-gas metal arc and resistance welding; silver brazing; soft soldering
AVAILABLE FORMS	Sheet, strip; rods, bars and shapes; tube; plate		
USES	Generally used in process equipment for resistance to corrosion and high temperatures. Also used in electronic equipment for vacuum tube parts, leads and springs	Equipment for production and handling of molten caustic soda and other molten salts. Spun or coined parts. Long time service at 700–1200 F	Parts requiring corrosion resistance and strength at elevated temperatures, such as springs, dies for extruding plastics, fasteners, vacuum tube components

[a] Values are for sheet and strip unless otherwise specified.

Nickel and Its Alloys—Wrought

Type ➡	Monel	K Monel	Inconel	Inconel X
COMPOSITION, %	Ni 66.00, C 0.12, Mn 0.90, Fe 1.35, S 0.005, Si 0.15, Cu 31.50	Ni 65.30, C 0.15, Mn 0.60, Fe 1.00, S 0.005, Si 0.15, Cu 29.50, Al 2.80, Ti 0.50	Ni 76.40, C 0.04, Mn 0.20, Fe 7.20, S 0.007, Si 0.20, Cu 0.10, Cr 15.85	Ni 72.80, C 0.04, Mn 0.70, Fe 6.75, S 0.007, Si 0.30, Cu 0.05, Cr 15.15, Al 0.80, Ti 2.55, Cb+Ta 0.85
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.319	0.306	0.304	0.298
Melting Temp Range, F	2370–2460	2400–2460	2540–2600	2540–2600
Ther Cond (80–212 F), Btu/hr/sq ft/°F/ft	15	10.8	8.7	8.7
Coef of Ther Exp (77–212 F), per °F	7.8×10^{-6}	7.8×10^{-6}	6.4×10^{-6}	9×10^{-6}
Spec Heat (70–750 F), Btu/lb/°F	0.127	0.127	0.109	0.10–0.11
Elec Res (68 F), microhm-cm	48.2	58.3	98.1	124.6 (122 F)
Magnetic?	Slightly magnetic	Nonmagnetic to −150 F	Nonmagnetic	Nonmagnetic
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi	26×10^{6}	26×10^{6}	31×10^{6}	31×10^{6}
Ten Str, 1000 psi				
Annealed	70–85	90–105	80–100	110–130
Annealed, Age Hardened	—	130–170	—	155–180
Spring	100–140	145–165	145–170	200–225
Spring, Age Hardened	—	170–200	—	250–285
Yld Str (0.2% offset), 1000 psi				
Annealed	25–45	40–65	30–45	45–65
Annealed, Age Hardened	—	90–120	—	100–125
Spring	90–130	130–160	120–160	230–240
Spring, Age Hardened	—	130–180	—	260–290
Elong (in 2 in.), %				
Annealed	50–35	45–25	55–35	40–55
Annealed, Age Hardened	—	25–15	—	30–20
Spring	15–2	8–3	10–2	1.6 (approx)
Spring, Age Hardened	—	10–5	—	1
Hardness (Rockwell)				
Annealed	B68 (max)	B85 (max)	B84 (max)	B95 (max)
Annealed, Age Hardened	—	C24–33	—	C30–37
Spring	B98 (min)	C25–32	C30 (min)	—
Spring, Age Hardened	—	C34–40	—	—
THERMAL TREATMENTS				
Annealing Temp, F	1600–1800 (open), 1400–1500 (box)	1400–1800 (1–5 min)	1600–1800	1900–2000 (15–30 min)
Solution Temp, F	—	—	—	2100 (2–4 hr, a.c.[c])
Aging Temp, F	—	1100 (8–16 hr, f.c.[c])	—	1550 (24 hr, a.c.), 1300 (20 hr, a.c.[c])
FABRICATING PROPERTIES				
Hot Working Temp Range (hot forging, drop forging), F	1700–2150	1900–2150	1700–2300	1800–2200
Cutting Speed, fpm[b]	125–225	100–200	100–175	—
Joining Methods	Metal arc, inert-gas metal arc, oxyacetylene and resistance welding; silver and copper brazing; soft soldering		Metal arc, inert-gas metal arc and resistance welding; silver brazing	
AVAILABLE FORMS	Sheet, strip, rod, bar, shapes, tube, plate			Sheet rod, bar, shapes
USES	Applications requiring combination of good strength, ductility and corrosion resistance. Condenser and heat exchanger tubes; pickling baskets, hooks and rods; pump shafts; valve stems; springs; fasteners	Applications requiring greater strength and hardness than monel with same corrosion resistance and strength comparable with that of mild steel. Pump shafts and liners, valve seats and stems, electrical contact arms	Food processing equipment, such as cookers, kettles, steamers and storage tanks. Other process equipment requiring similar combination of strength, corrosion resistance and good elevated temperature properties	High strength, high temperature alloy (can operate extended periods at 1000 F) for application in steam turbines, jet engines, heat treating equipment. Furnace muffles, springs, turbine blades, bellows, fasteners

[a] Values are for sheet and strip unless otherwise specified.

[b] Surface speed with single point cemented carbide tools.

[c] a.c.—air cool, f.c.—furnace cool.

Low-Expansion Nickel Alloys—Wrought

Composition (%)[a] →	Ni 36	Ni 42	Ni 47-50
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.292	0.292	0.296
Melting Point, F	2600	2606	2600
Ther Cond (68–212 F), Btu/hr/sq ft/°F/ft	6.05	6.21	6.91
Coef of Ther Exp, per °F			
−200 to 0 F	1.10×10^{-6}	3.42×10^{-6}	5.37×10^{-6}
0 to 200 F	0.70×10^{-6}	3.18×10^{-6}	5.55×10^{-6}
200 to 400 F	1.50×10^{-6}	2.97×10^{-6}	5.55×10^{-6}
400 to 600 F	6.35×10^{-6}	3.15×10^{-6}	5.55×10^{-6}
600 to 800 F	8.61×10^{-6}	5.50×10^{-6}	5.60×10^{-6}
800 to 1000 F	9.48×10^{-6}	8.55×10^{-6}	7.26×10^{-6}
Specific Heat (77–212 F), Btu/lb/°F	0.123	0.121	0.120
Electrical Resistivity (68 F), microhm-cm	81	70	48
Poisson's Ratio	0.290	0.290	0.290
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	21×10^6	22×10^6	24×10^6
Tensile Strength, 1000 psi			
Annealed	70	76	82
Cold Worked	90	120	140
Yield Point, 1000 psi			
Annealed	24	28	31
Cold Worked	70	—	—
Elongation (in 2 in.), %			
Annealed	36	38	41
Cold Worked	20	—	—
Reduction of Area, %			
Annealed	68	70	72
Cold Worked	60	—	—
Hardness			
Annealed (Brinell)	143	156	170
Cold Worked (Rockwell)	—	B100	B103
Modulus of Rigidity, psi	8.1×10^6	8.5×10^6	9.3×10^6
FABRICATING PROPERTIES			
Annealing Temp, F	Soften progressively in range 1000 to 2300 F		
Hot Working Temp Range, F	To 2300 F	To 2300 F	To 2300 F
Machinability	Machine best at a hardness of about Rockwell C20		
Weldability	Can be welded by acetylene torch, metal arc, carbon arc and resistance methods		
CORROSION RESISTANCE	Resistant to atmospheric corrosion and to fresh and salt water		
AVAILABLE FORMS	Bar, plate, sheet, strip, wire, tubing, forgings, castings		
USES	Length standards, instruments, hypodermic syringes, textile machine parts, thermostatic bimetal — up to 400 F	Higher temperature thermostatic bimetal, instruments, glass sealing — up to 650 F	Higher temperature low expansion applications—up to 1000 F

[a] Balance iron.

Nickel Alloys—Cast

Type ➜	Nickel	Inconel	S Inconel	Monel	S Monel
COMPOSITION, %	Ni 95.6, Cu 0.5, Fe 0.5, Si 1.5, Mn 0.8, C 0.80, S 0.008	Ni 71.5, Cu 0.50, Fe 8.0, Cr 16.0, Si 2.0, Mn 1.0, C 0.20, S 0.008	Ni 68.0, Cu 0.5, Fe 8.5, Mn 1.0, Si 5.5, Cr 15.5, S 0.008, C 0.20	Ni 63.0, Cu 32.0, Fe 1.5, Si 1.6, Mn 0.75, C 0.15, S 0.015	Ni 63.0, Cu 30.0, Fe 2.0, Si 4.0, Mn 0.75, C 0.1, S 0.015
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.301	0.300	0.292	0.312	0.302
Melting Temp Range, F	2450–2600	2500–2550	—	2400–2450	2300–2350
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	34.2	8.7	—	15.5	11.3
Coef of Ther Exp (70–1400 F), per °F	8.85×10^{-6}	8.92×10^{-6}	9.20×10^{-6}	9.0×10^{-6}	8.7×10^{-6}
Spec Ht (80–750 F), Btu/lb/°F	0.13	0.11	—	0.13	0.13
Elec Res (32 F), microhm-cm	20.8	11.6	12.6	53.2	63.1
Magnetic Trans Temp, F	680	−40	—	110–140	−70
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	21.5×10^6	23×10^6	25×10^6	23.0×10^6	24.2×10^6
Mod of Elast in Torsion, psi	11.0×10^6	11.0×10^6	—	9.5×10^6	9.5×10^6
Ten Str, 1000 psi					
Annealed & Aged	—	—	75–30	—	120–145
As Cast	50–65	65–90	90–120	65–90	120–145
Yld Str (0.5% ext), 1000 psi					
Annealed & Aged	—	—	55–70	—	85–130
As Cast	15–30	—	80–100	32–45	80–130
Elong (in 2 in.), %					
Annealed & Aged	—	—	4–1	—	1–4
As Cast	30–15	20–10	3–1	20–50	1–4
Hardness (Brinell)					
Annealed & Aged	—	—	300–380	—	300–380
As Cast	90–130	150–300	300–380	125–150	275–350
Impact Str (Charpy, rm temp), ft-lb	90–75	24	—	80–65	9–3
FABRICATING PROPERTIES					
Pouring Temp, F	2700–2900	2800–2950	2700–2900	2700–2850	2650–2800
Pattern Shrinkage, in./ft	0.25	0.25	0.25	0.25	0.25
Weldability	Fabrication or repair by any standard process[a]	Repair welding by any standard process[a]	Not recommended	Limited amount of repair welding[a]	Not recommended
CORROSION RESISTANCE	Good corrosion resistance, especially to hot concentrated caustic soda, and chlorine and fluorine gases	Resistance to nitric acid, ammonium hydroxide and oxidizing conditions superior to that of nickel. Good resistance to oxidation at temperatures up to 2200 F. Good resistance to corrosive vapors above 800 F		Good resistance to flowing salt water; dilute acids; hydrochloric, hydrofluoric, sulfuric, phosphoric and most organic acids; and strong caustic soda. Not resistant to strongly oxidizing solutions such as nitric acid and ferric chloride	
USES	Evaporators, tanks, heating coils, tubular condensers and other processing equipment; magnetostrictive devices; applications in incandescent lamp and radio industries	Dairy equipment, food handling equipment, airplane exhaust manifolds, utensils. Used extensively in oxidizing and carburizing atmospheres at elevated temperatures. Inconel S castings have higher resistance to wear and galling than Inconel		Valve seats, liners, pump rods, bushings, nozzles, turbine blading, pickling equipment, laundry machines, paper mill and oil refinery equipment, food handling equipment, storage tanks, boilers. Monel S castings have higher resistance to galling and erosion than Monel	

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[a] For joining by welding, a weldable grade is available.

Precious Metals—Wrought

Metal →	Gold[a]	Silver[b]	Platinum[c]	Palladium[b]
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.698	0.379	0.775	0.434
Melting Point, F	1945	1761	3224	2829
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	172	242	42	41
Coef of Ther Exp (32–212 F), per °F	7.9×10^{-6}	10.9×10^{-6}	4.9×10^{-6}	6.5×10^{-6}[a]
Spec Ht, Btu/lb/°F	0.031	0.056	0.031	0.058
Elec Res (32 F), microhm-cm	2.35	1.59[d]	14.9	10.8[a]
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	12×10^{6}	11×10^{6}	21×10^{6}	17×10^{6}
Ten Str, 1000 psi				
Annealed	19	22	17-26	30
Cold Worked	32[e]	54[f]	34-45	47
As Cast	18	15	—	—
Yld Str, 1000 psi				
Annealed	Nil	8	2-5.5	5
Cold Worked	30	44	27	30
As Cast	—	5	—	—
Elong (in 2 in.), %				
Annealed	45	48	30-40	24-40
Cold Worked	4	2.5	2.5-3.5	1.5
As Cast	30	60	—	—
Red. of Area (as cast), %	—	67	—	—
Hardness (Brinell)				
Annealed	25	25–35	38-52	46
Cold Worked	58	—	97-13	109
As Cast	33	42	—	—
Endurance Limit (10^{7} cycles, annealed), 1000 psi	4.6	—	—	—
FABRICATING PROPERTIES				
Annealing Temp, F	—	400-600	1475-2200	1475
Hot Working Temp Range, F	Any to melting point	—	1475-2300	1475-2300
Max Red. Between Anneals, %	Apparently unlimited	—	99	99
Casting Temp Range, F	2000-2370	2000	3300	3000
Joining	Braze with silver solder, no flux, any flame. Can be resistance welded by any method. Oxyacetylene weld with no flux, any flame	Braze with silver solder. Can be resistance welded	Braze with fine gold or white platinum solder. Hammer weld at 1800 F. Can be resistance or oxyacetylene welded	Braze with oxyacetylene torch using platinum solders. Can be resistance welded
CORROSION RESISTANCE	Does not oxidize when heated in air. Resists alkalis, salts and most acids. Not attacked by oxygen or sulfur. Rapidly attacked by chlorine and bromine	Does not oxidize when heated in air. Resists most dilute mineral acids and alkalis. Attacked rapidly by nitric and hot sulfuric acids. Attacked rapidly by sulfur-bearing gases	Does not oxidize when heated in air. Resists reducing or oxidizing acids alone but is dissolved by aqua regia	Oxidizes when heated in air. Resists hydrofluoric, acetic and phosphoric acids. Attacked by nitric, sulfuric and hydrochloric acids; and bromine and iodine
AVAILABLE FORMS	Foil, rod, wire, sheet	Sheet, strip, rod, wire, tubing	Foil, sheet, wire, tubing	Sheet, foil, wire, tubing
USES	Lining of chemical equipment, high melting solder, alloys for electrical and chemical purposes, jewelry, dentistry	Electrical contacts, corrosion resisting equipment, bearings, photography supplies; alloying for coinage, brazing alloys, jewelry	Chemical equipment, electrical contacts, catalysts, laboratory equipment, jewelry	Electrical contacts, catalysts, production of pure hydrogen, jewelry, dental alloys

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[a] Gold is generally produced in three grades: proof gold, 99.99% Au; refined gold, 99.95-99.98% Au; and 99.5% Au, which is accepted by the U.S. Mint without penalty.

[b] Usually refined to "the high purity suitable for general use"; in some cases spectographically pure.

[c] Platinum is produced in four grades: type A, 99.99% Pt, sometimes called physically pure; type B, 99.9% Pt, sometimes called chemically pure; type C, 99.5% Pt (crucible grade); and type D, 99% Pt (commercial platinum).

[d] 68 F. [e] Cold rolled, 60% reduction. [f] Cold rolled, 50% reduction.

Precious Metals—Cast, Wrought

Metal ⇒	Rhodium[b]	Ruthenium[b]	Osmium[b]	Iridium[b]
PHYSICAL PROPERTIES				
Density, lb/cu in	0.447	0.441	0.82	0.813
Melting Point, F	3571	4530	4890	4450
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	50	—	—	34
Coef of Ther Exp (68 F), per °F	4.6×10^{-6}	5.1×10^{-6}	3.6×10^{-6}	3.8×10^{-6}
Specific Heat, Btu/lb/°F	0.059	0.057	0.031	0.031
Elec Res (68 F), microhm-cm	4.51	7.6[g]	9.5	5.3
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	42×10^{6}	60×10^{6}	80×10^{6}	74×10^{6}
Ten Str, 1000 psi				
Annealed	73	—	—	—
Cold Worked	300	—	—	—
Hardness (Brinell)				
Annealed	55–156	—	—	170
Cold Worked	260–390	—	—	350
As Cast	—	220	350	163
FABRICATING PROPERTIES				
Hot Working Temp Range, F	1900–2000	2700–4300	Not workable	2200–2700
Max Red. Between Anneals, %	30–40	—	—	—
Casting Temp, F	3700	4700	5000	4600
Joining	Can be brazed and resistance welded	Can be brazed and resistance welded	Can be brazed and resistance welded	Can be brazed and resistance welded
CORROSION RESISTANCE	Oxidizes slowly when heated in air. Resistant to most acids, including aqua regia at room temperature	Oxidizes when heated in air. Unattacked by common acids, including aqua regia up to 212 F. Moderately attacked by solutions of alkaline hypochlorites	Oxidizes rapidly in air at elevated temperatures. Resists common acids at room temperatures, but is attacked by aqua regia	Oxidizes slowly when heated in air. Unattacked by common acids, including aqua regia up to 212 F
AVAILABLE FORMS	Powder	Powder	Cast or sintered parts	Sheet, wire, rod
USES	Mirrors and electrodeposits for a nontarnishing finish; alloys with platinum and palladium for crucibles, glassworking equipment, catalysts, spinnerets	Hardener for platinum and palladium	Alloys used for pen tips, phonograph needles, electrical contacts, instrument pivots	Extrusion dies for glass, alloys with platinum for electrical contacts, fuse wires, hypodermic needles, jewelry

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[b] Usually refined to "the high purity suitable for general use"; in some cases spectrographically pure.
[g] At 32 F.

Tin and Its Alloys—Cast, Wrought

Type ⇨	Grade A Tin	Hard Tin	Tin Foil	White Metal	Pewter
COMPOSITION, %	Sn 99.8 min	Sn 99.6, Cu 0.4	Sn 92, Zn 8	Sn 92, Sb 8	Sn 91, Sb 7, Cu 2
PHYSICAL PROPERTIES					
Density, lb/cu in	0.264	—	—	0.262	0.263
Melting Temp Range, F	449.4	446–441	390	475	563–471
Ther Cond (77 F), Btu/hr/sq ft/°F/ft	37	—	34	—	—
Coef of Ther Exp (32–212 F), per °F	13×10^{-6}	—	—	—	—
Spec Ht, Btu/lb/°F	0.054	—	—	—	—
Elec Res (68 F), microhm-cm	11.5	—	12	15	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	$6–6.5 \times 10^{6}$	—	—	—	7.7×10^{6}
Ten Str, 1000 psi					
Annealed Sheet	2.2	3.3	—	6.7	8.6
Cold Rolled Sheet	2.8	4.0	8.7	7.4[b]	7.6
As Cast	2.1	—	—	7.2[c]	—
Yld Str, 1000 psi					
Annealed Sheet	1.3	—	—	—	—
Cold Rolled Sheet	2.0	—	6.0	—	—
As Cast	1.7	—	—	—	—
Elong (in 2 in.), %					
Annealed Sheet	45	—	—	70	40
Cold Rolled Sheet	35	—	40	28[b]	50
As Cast	55[a]	—	—	—	—
Hardness (Brinell)					
Annealed Sheet	7	—	—	17	13[d, f]
Cold Rolled Sheet	8	—	—	—	18[e, f]
As Cast	5–6	—	—	20[c]	23[d, f]
Impact Str (Izod, as cast), ft-lb	14	—	—	22[c]	—
Endurance Limit (as cast), 1000 psi	0.34	—	—	—	—
FABRICATING PROPERTIES					
Casting Temp Range (chill), F	525–550	525–550	—	575–600	600–625
Joining	Bonds easily by simple melting. Eutectic tin-lead solder or low melting fusible alloys might be used on massive parts such as block tin pipe		—	Readily soldered	Can be soldered with some of the fusible alloys
CORROSION RESISTANCE	Resists distilled, sea and soft tap water. Attacked by strong acids, alkalis and acid salts. Oxygen in solution accelerates rate of attack		—	—	Tarnishes in soft water; suffers localized attack at water line in hard water. Attacked by dilute hydrochloric and citric acids in presence of air
AVAILABLE FORMS	Sheet, pipe, foil, castings, powder	Tubing, foil	Foil	Castings, sheet	Castings, sheet
USES	Linings for food cans; pipe for handling water, beer, and carbonated beverages; linings for food processing equipment, food wrappings	Collapsible tubes, foil	Foil for wrapping food, medicines, electrical condensers	Rubber mold castings, cast and wrought costume jewelry	Mountings and ornamental objects such as tea and coffee services, vases and book ends

[a] In 4 in.
[b] Sheet quenched from 425 F.
[c] Chill cast.
[d] Vickers pyramid hardness.
[e] Vickers pyramid hardness after heat treating 3 hr at 300 F.
[f] Hardenable pewter values are: 13, 28, 29, respectively.

Tin-Lead-Antimony Alloys—Cast

Grade[a] ➡	1[b]	2	3	4	5[c]
COMPOSITION, %	Sn 91, Sb 4.5, Cu 4.5	Sn 89, Sb 7.5, Cu 3.5	Sn 84, Sb 8, Cu 8	Sn 75, Pb 10, Sb 12, Cu 3	Sn 65, Pb 18, Sb 15, Cu 2
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.265	0.267	0.269	0.272	0.280
Melting Temp Range, F	433–700	466–669	464–792	363–583	358–565
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	7.3×10^6	7.6×10^6	—	—	—
Ten Str, 1000 psi					
Chill Cast	9.3	11	10–12	—	—
Die Cast	10.3	—	—	—	11.8
Elong (in 2 in., die cast), %	22	—	—	—	4
Hardness (Brinell)					
Chill Cast	17	24	27	25	22
Die Cast	—	—	—	—	27.7
Impact Str (Izod, chill cast), ft-lb	2.5	—	1	—	—
Endur Limit (chill cast), 1000 psi	3.8[d]	4.8[d]	—	—	—
Compr Str (chill cast, 25% set), 1000 psi	13	15	18	16	15
Compr Yld Str (chill cast, 0.125% set), 1000 psi	4.4	6.1	6.6	5.5	5.0
FABRICATING PROPERTIES					
Casting Temp Range (chill), F	750–825	795	850–915	710	690–700
CORROSION RESISTANCE	Resists oxidation products of lubricants; food products, beer and carbonated beverages	Resist oxidation products of lubricants			
AVAILABLE FORMS	Precision inserts of babbitt-lined strip, lined bearing shells, ingots, die castings			Ingots	Ingots, die castings
USES	Bearings, die castings for dairy machinery, dental appliances, surgical instruments, soda fountain equipment	Most widely used tin-base bearing alloy in automotive field	High load applications, hardest of standard tin babbitts and has greatest load carrying capacity	Limited bearing applications	Limited bearing applications Die cast parts

[a] ASTM B23-49.
[b] Also die casting Alloy 1, ASTM B102-48.
[c] Also die casting Alloy 3, ASTM B102-48.
[d] 2×10^7 cycles.

continued on next page

Tin-Lead-Antimony Alloys—Cast

Grade[a] ➜	6	7	8	10	11
COMPOSITION, %	Sn 20, Sb 15, Pb 63.5, Cu 1.5	Sn 10, Sb 15, Pb 75	Sn 5, Sb 15, Pb 80	Sn 2, Sb 15, Pb 83	Sb 15, Pb 85
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.336	0.350	0.361	0.362	0.370
Melting Temp Range, F	531-358	514-464	522-459	507-468	504-471
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	14	14	—	—
Coef of Ther Exp (68-212 F), per °F	—	10.9×10^{-6}	13×10^{-6}	—	—
Spec Ht, Btu/lb/°F	—	0.065	0.065	—	—
Elec Res (68 F), microhm-cm	—	28.6	28.2	—	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	—	4.2×10^6	4.2×10^6	—	—
Ten Str, 1000 psi[e]	—	10.5	10	—	6.8
Elong (in 2 in.), %[e]	—	4	5	—	8
Hardness (Brinell)[e]	21	22	20	18	15
Endurance Limit, 1000 psi[e]	—	4[d]	3.9[d]	—	—
Compr Str (25% deformation), 1000 psi[e]	14.5	15.6	15.6	15.4	12.8
Compr Yld Str (0.125% set), 1000 psi[e]	3.8	3.6	3.4	3.4	3.0
FABRICATING PROPERTIES					
Casting Temp (chill), F	655	640	645	630	630
CORROSION RESISTANCE	Resistant to corrosion by the usual lubricants				
AVAILABLE FORMS	Small ingots and bars				
USES[f]	General purpose bearing applications	General purpose bearings under moderate loads	Bearings for light loads and moderate speeds. Mining machinery, transmission machinery, car journals	Bearings for light loads and speeds. Blowers, pumps, electric motors, machine tools	Bearings for light loads

[a] ASTM B23-49.

[d] 2×10^7 cycles.

[e] Chill cast.

[f] Light loads—under 1000 psi; moderate loads—1000 to 2000 psi; heavy loads—over 3000 psi. Surface speeds: low—to 10 fps; moderate—to 20 fps; high—above 30 fps.

Tin-Lead-Antimony Alloys—Cast

Grade[a] →	12	15	16	19
COMPOSITION, %	Sb 10, Pb 90	Sn 1, Sb 15, Cu 0.5, As 1.0, Pb bal	Sn 10, Sb 12.5, Cu 0.5, Pb bal	Sn 5, Sb 9, Pb bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.384	0.362	0.355	0.378
Melting Temp Range, F	498–473	538–479	495–471	495–462
Coef of Ther Exp (68–212 F), per °F	14.6×10^{-6}	—	—	—
Specific Heat, Btu/lb/°F	0.065	—	—	0.065
Elec Res (68 F), microhm-cm	25.6	—	—	28.7
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	—	4.2×10^6	—	4.2×10^6
Tensile Strength, 1000 psi[e]	—	10.4	—	10
Elongation (in 2 in.), %[e]	—	2	—	5
Hardness (Brinell)[e]	14	21	28	18
Endurance Limit, 1000 psi[e]	—	4.3[d]	—	3.7[f]
Compressive Strength (25% deformation), 1000 psi[e]	12.9	—	—	15.6
Compressive Yield Strength (0.125% set), 1000 psi[e]	2.8	—	—	—
FABRICATING PROPERTIES				
Casting Temp (chill), F	625	660	620	620
CORROSION RESISTANCE	Resistant to corrosion by the usual lubricants			
AVAILABLE FORMS	Small ingots and bars			
USES[f]	Bearings for light loads	Bearings for high loads and speeds. Diesel engines, automotive engines, steamships, various types of machines	Bearings for moderate loads and speeds	Bearings for light loads and speeds. Car journal bearings

[a] ASTM B23–49.

[e] Chill cast.

[f] Light loads—under 1000 psi; moderate loads—1000 to 2000 psi; heavy loads—over 3000 psi. Surface speeds: low—to 10 fps; moderate—to 20 fps; high—above 30 fps. 2×10^7 cycles.

Titanium and Its Alloys—Wrought

Type ➡	Unalloyed	5 Al–2.5 Sn	8 Mn	3 Mn–1.5 Al	4 Mn–4 Al
COMPOSITION, %	Ti 99.0	Al 5.0, Sn 2.5	Mn 7.9	Al 1.5, Mn 3.0	Al 4.0, Mn 4.0
PHYSICAL PROPERTIES					
Density, lb/cu in	0.163	0.161	0.170–0.172	0.168	0.163–0.165
Melting Temp Range, F	3135	2822–3002	2730–2970	—	2822–3002
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.8	4.85	6.7	—	4.9
Coef of Ther Exp (68–1650 F), per °F	5.8×10^{-6}	5.7×10^{-6}	7.1×10^{-6}	—	$5.7–6.3 \times 10^{-6}$
Spec Ht (68 F), Btu/lb/°F	0.130	0.131	0.118	—	0.133
Elec Res (68 F), microhm-cm	55.0	157.3	90.7	—	146.1
Magnetic Permeability (20 oersteds)	1.00005	1.00005	1.00005	—	1.00005
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	$15–15.5 \times 10^6$	15.5×10^6	15.9×10^6	15×10^6	15.9×10^6
Ten Str, 1000 psi	89–100	125	126–135	125	145–150
Yld Str, 1000 psi	80–82	120	118–120	116	135–142
Elong (in 2 in.), %	15–22	18	15–18	18	14–15
Red. of Area, %	40–45	40	32	—	35–40
Hardness (Rockwell)	C30	C30–35	C28–34	C26–32	C30–36
Impact Str (Charpy), ft-lb	20–35	18–20	—	15–20	11–15
Endurance Limit, 1000 psi					
Sheet (unnotched)	43	95	90	—	—
Bar (unnotched)	60–62	—	—	—	75–90
Bar (notched)	37	—	—	—	32[f]
Compr Yld Str, 1000 psi	—	—	120	—	—
Mod of Rigidity, psi	5.6×10^6	—	6×10^6	—	6.27×10^6
THERMAL TREATMENT					
Annealing Temp, F	850–1250	1500–1600	900–1250	1250	1300
Stress Relieving Temp, F	700–1000	1000–1200	<700 or at 1000	—	—
FABRICATING PROPERTIES					
Hot Working Temp Range, F	300–800	1000	500–600	—	—
Forging Temp, F	1300–1600	1400–1900	—	1300–1700	1300–1750
Fusion Weldability[d]	Yes	Yes[d]	No	Marginable	Questionable
Formability (sheet, 78 F)[e]	High	Intermediate	Intermediate	Moderate	Bar only
CORROSION RESISTANCE	Superior resistance to nitric acid, moist chlorine, chlorine solutions, chlorinated organic compounds, and inorganic chloride solutions. Excellent resistance to corrosive attack by sea water and most chloride salt solutions—unchallenged by other structural metals. Resists impingement, pitting attack				
AVAILABLE FORMS	Sheet, strip, plate, tubing, billets, bar, wire	Sheet, strip, plate, wire, bar	Sheet, strip, plate	Sheet, plate, billets, bar, wire	Billets, bar, forgings, plate, wire
USES	Military aircraft parts requiring corrosion resistance and high strength-to-weight ratio up to 800 F. Naval and marine applications; chemical, pharmaceutical and food processing and handling equipment; marine diesel engine mufflers; springs (high proportional limit and low modulus of elasticity), rivets, bolts, nuts, screws and fittings; ordnance and sporting equipment; orthopedic and orthodontic equipment				

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[a] Annealed condition unless otherwise stated.

[d] Some users report difficulty in producing welds without porosity; others do not.

[e] All titanium sheet is formed with considerably less difficulty at elevated temperatures. Forming can be accomplished at temperatures in the 500 to 1000 F range with no need for postforming surface treatment, provided time at temperature is short.

[f] k = 3.9.

Titanium and Its Alloys—Wrought

Type ➡	7 Al–4 Mo	16 V–2.5 Al	4 Al–3 Mo–1 V	13 V–11 Cr–3 Al	6 Al–4 V
COMPOSITION, %	Al 7.0, Mo 4.0	V 16.0, Al 2.5	Al 4.0, Mo 3.0, V 1.0	V 13.0, Cr 11.0, Al 3.0	Al 5.5–6.3, V 3.5–4.5
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.162	0.168	0.161	0.175	0.160
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	3.7	—	—	3.9	—
Coef of Ther Exp (68–1650 F), per °F	4.9×10^{-6}[f]	—	—	5.2×10^{-6}[f]	5.8×10^{-6}
Spec Ht (212 F), Btu/lb/°F	0.123	—	—	0.131	—
Elec Res (68 F), microhm-cm	175	—	—	—	—
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension (200 F), psi	16.7×10^6	15×10^6	—	14.3×10^6	—
Ten Str (68 F), 1000 psi					
Annealed	155–170	110–115	140	140	130–140
Heat Treated	—	175–180	190	190–240	170
Yld Str (68 F), 1000 psi					
Annealed	145–155	40–55	90	135	120–130
Heat Treated	—	160–165	168	135–220	150
Elong (in 2 in.), %					
Annealed (68 F)	13–18	15–20	16	15	10–13
Heat Treated	—	6–10	8	15–2	13
Red. of Area (68 F), %					
Annealed	30–45	65	—	40	25–40
Heat Treated	—	35	—	—	40
Hardness (Rockwell)					
Annealed	—	—	—	—	C33–36
Heat Treated	—	—	—	—	C38
Impact Str (Charpy, 68 F), ft-lb	10–20	—	—	8	15–25
Endurance Limit (10^8 cycles), 1000 psi					
Bar (unnotched)	93	—	—	—	70
Bar (notched)	29	—	—	—	35
Sheet (notched)	—	—	—	34	—
Shear Str, 1000 psi	104–115	—	—	—	—
THERMAL TREATMENT					
Annealing Temp, F	1450–1650	—	1500–1675	1400	—
FABRICATING PROPERTIES					
Hot Working Temp Range, F	—	—	—	200–400	—
Forging Temp, F	1400–1850	—	—	—	—
Fusion Weldability	No	—	Limited	Yes	Marginal
Formability (sheet, 78 F)[e]	—	High	High	High	Intermediate
CORROSION RESISTANCE	Superior resistance to nitric acid, moist chlorine, chlorine solutions, chlorinated organic compounds and inorganic chloride solutions. Excellent resistance to sea water and most chloride salt solutions unchallenged by other structural metals. Resist impingement, pitting attack				
AVAILABLE FORMS	Bar, rod, forgings	Sheet, bar	Sheet	Sheet, strip, wire	Bar, sheet, strip
USES	Military aircraft parts requiring corrosion resistance and high strength-to-weight ratio up to 800 F. Naval and marine applications; chemical, pharmaceutical and food processing and handling equipment; marine diesel engine mufflers; springs (high proportional limit and low modulus of elasticity), rivets, bolts, nuts, screws and fittings; ordnance and sporting equipment; orthopedic and orthodontic equipment				

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[a] Annealed condition unless otherwise stated. [b] 60-deg notch, 0.010-in. radius, $k = 2.7$. [c] $k = 4.0$.

[d] Some users report difficulty in producing welds without porosity; others do not.

[e] All titanium sheet is formed with considerably less difficulty at elevated temperatures. Forming can be accomplished at temperatures in the 500 to 1000 F range with no need for postforming surface treatment, provided time at temperature is short.

[f] 68–200 F.

Zinc Alloys—Wrought

Type ➡	Commercial Rolled Zinc (deep drawing)	Commercial Rolled Zinc	Commercial Rolled Zinc	Copper Hardened Rolled Zinc Alloy	Rolled Zinc Alloy
COMPOSITION, %	Pb 0.10 max, Zn bal	Pb 0.05–0.10, Cd 0.05–0.08, Zn bal	Pb 0.25–0.50, Cd 0.25–0.45, Zn bal	Cu 0.85–1.25, Zn bal	Cu 0.85–1.25, Mg 0.006–0.016, Zn bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.258	0.258	0.258	0.259	0.259
Melting Point, F	786	786	786	792	792
Ther Cond (64 F), Btu/hr/sq ft/°F/ft	62.2	62.2	—	—	60.5
Coef of Ther Exp, per °F					
With Grain	18.1 x 10^{-6}	18.1 x 10^{-6}	18.8 x 10^{-6}	—	19.3 x 10^{-6}
Across Grain	12.8 x 10^{-6}	12.8 x 10^{-6}	13.0 x 10^{-6}	—	11.7 x 10^{-6}
Spec Ht (68–212 F), Btu/lb/°F	0.094	0.094	0.094	0.0957	0.0957
Elec Res (68 F), microhm-cm					
Hot Rolled	6.06	—	—	6.22	6.31
Cold Rolled	6.10	—	—	—	—
MECHANICAL PROPERTIES					
Ten Str, 1000 psi[a]					
Hot Rolled	19.5, 23	21, 25	23, 29	24, 30	29, 40
Cold Rolled	21, 27	22, 29	25, 31	31, 40	36, 46
Elong (in 2 in.), %[a]					
Hot Rolled	65, 50	52, 30	50, 32	50, 35	20, 10
Cold Rolled	50, 40	40, 30	45, 28	44, 30	25, 10
Hardness (Brinell)					
Hot Rolled	38	43	47	52	61
Cold Rolled	—	—	—	60	80
Endurance Limit (hot rolled), 1000 psi	2.5	3.8	4.1	6.1	6.8
FABRICATING PROPERTIES					
Hot Working Temp Range, F	248–527	248–527	248–437	447–572	447–572
Melting Range, F	887–977	887–977	887–977	887–977	887–977
Ingot Casting Range, F	815–905	815–905	815–905	815–905	815–905
Annealing Temp, F	—	—	221	347	347
Machinability	Good	Good	Good	Good	Good
Joining					
Torch Welding	Poor to fair	Poor to fair	Poor to fair	Poor to fair	Poor to fair
Single Impulse Resistance Welding	Poor	Poor	Poor	Poor	Poor
Multiple Impulse Resistance Welding	Fair to good	Fair to good	Fair to good	Fair to good	Fair to good
Soldering	Good	Good	Good	Good	Good
Common Processes	Drawing, bending, roll forming				
	Spinning, swaging, impact extrusion		Swaging, impact extrusion	Spinning, swaging	
CORROSION RESISTANCE	Excellent resistance to both metropolitan and rural atmospheric corrosion (penetration in in. per yr is 0.000064 in Palmerton, Pa., and 0.00028 in New York City); also hot soapy water, printing inks, trichloroethylene, carbon tetrachloride, dry illuminating gas, and moisture- and acid-free hydrocarbons. Fair resistance to pure ethyl and methyl alcohols, glycerine, water, petroleum products. Poor resistance to steam, spray insecticides, animal oils, strong acids and bases, and mixtures of glycerine or alcohol and water				
AVAILABLE FORMS	Rolled strip and sheet; extruded rod and shapes; drawn rod and wire				
USES	Drawn battery cans, eyelets, grommets, laundry tags, address plates, flashing		Soldered battery cans, photoengravers' and lithographers' sheets	Weatherstrip, nameplates, ferrules. Drawn, formed or spun parts requiring stiffness	Corrugated roofing, flat, drawn or moderately formed parts requiring maximum stiffness
	Drawn, formed or spun parts not requiring stiffness	Drawn, formed or spun parts requiring some rigidity			

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[a] Two values represent properties parallel to grain and perpendicular to grain, in that order.

Zinc Alloys—Cast

Type ➡	Alloy XXIII[a]	Alloy XXV[a]	Slush Casting Alloy[b]	Slush Casting Alloy (unbreakable metal)[b]
COMPOSITION, %	Al 3.5–4.3, Mg 0.03–0.08, Zn[c] bal	Al 3.5–4.3, Cu 0.75–1.25, Mg 0.03–0.08, Zn[c] bal	Al 4.5–5.0, Cu 0.2–0.3, Zn[c] bal	Al 5.25–5.75, Zn[c] bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.24	0.24	—	—
Melting Point, F	728	727	734	743
Ther Cond (158–284 F), Btu/hr/sq ft/°F/ft	65.3	62.9	—	—
Coef of Ther Exp (68–212 F), per °F	15.2×10^{-6}	15.2×10^{-6}	—	—
Spec Ht (68–212 F), Btu/lb/°F	0.10	0.10	—	—
Elec Res (68 F), microhm-cm	6.37	6.54	—	—
MECHANICAL PROPERTIES[d]				
Ten Str, 1000 psi				
Die Cast	41	47.6	—	—
Chill Cast	—	—	28.0	25.0
Elong (in 2 in.), %				
Die Cast	10	7	—	—
Chill Cast	—	—	—	1
Hardness (Brinell, die cast)	82	91	—	—
Impact Str (Charpy), ft-lb				
Die Cast	43	48	—	—
Chill Cast	—	—	3	1
Endurance Limit (10^8 cycles, die cast), 1000 psi	6.9	8.2	—	—
Compr Yld Str (die cast), 1000 psi	60	87	—	—
Shear Str (die cast), 1000 psi	31	38	—	—
FABRICATING PROPERTIES				
Melting Temp Range, F	728–932	727–932	—	—
Die Casting Temp Range, F	740–800	740–800	—	—
Solidification Shrinkage, %	1.17	1.17	—	—
Machinability	Good	Good	Good	Good
Joining				
Torch Welding	Poor to fair	Poor to fair	—	—
Single Impulse Resistance Welding	Poor	Poor	—	—
Multiple Impulse Resistance Welding	Fair to good	Fair to good	—	—
Soldering	Poor[e]	Poor[e]	—	—
Common Fabrication Processes	Welding, soldering, machining, riveting, spinning, cold swaging		Welding, soldering, machining	
CORROSION RESISTANCE	Excellent resistance to both metropolitan and rural atmospheric corrosion[f]; also hot soapy water, printing inks, trichloroethylene, carbon tetrachloride, dry illuminating gas, and moisture- and acid-free hydrocarbons. Fair resistance to pure ethyl and methyl alcohols, glycerine, water and petroleum products. Poor resistance to steam, spray insecticides, animal oils, strong acids and bases, and mixtures of glycerine or alcohol and water			
USES	Automotive parts, household utensils, office equipment, building hardware, padlocks, toys, novelties, drop hammer dies (XXV)		Slush and permanent mold castings, principally for lighting fixtures	

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[a] ASTM B86-53T.

[b] Because of their limited use, few data are available on these alloys.

[c] Special high grade zinc is required.

[d] Based on a ¼-in. section for die cast alloys; a ½-in. section for chill cast alloys.

[e] Cadmium-zinc and lead-tin solders diffuse into the casting, promoting subsurface attack. Castings must be nickel plated to be joined by lead-tin solders.

[f] Penetration in in. per yr in Palmerton, Pa., and New York City, respectively, is 0.78×10^{-4} and 2.2×10^{-4} for XXIII, and 0.68×10^{-4} and 2.8×10^{-4} for XXV.

Columbium, Tantalum, Tungsten, Molybdenum, Beryllium—Wrought

Metal →	Columbium	Tantalum	Tungsten	Molybdenum	Beryllium
PHYSICAL PROPERTIES					
Density, lb/cu in	0.31	0.60	0.70	0.37	0.067
Melting Point, F	4379	5425	6152	4760	2341
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	31.5	31.5	96.6	84.5	87
Coef of Ther Exp (70 F), per °F	3.82×10^{-6}[a]	3.6×10^{-6}	2.2×10^{-6}	3.0×10^{-6}	6.4×10^{-6}
Specific Heat, Btu/lb/°F	0.065	0.036	0.034	0.065	0.45
Elec Res (68 F), microhm-cm	14.2	12.4	5.48[b]	5.17[b]	5
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	—	27×10^{6}	50×10^{6}	42×10^{6}	44×10^{6}
Ten Str, 1000 psi					
Annealed	50	50–100	—	85–130[c], 88[d]	60–90[e]
Cold Worked	100	110–180	70–300	120–175[c]	—
Yld Str, 1000 psi					
Annealed	—	—	—	—	45–55[e]
Cold Worked	—	—	—	—	—
Elong (in 2 in.), %					
Annealed	30	11–40	—	4–7[c], 42[d]	2–5[e]
Cold Worked	5	1–1.5	0	1[c]	—
Hardness (Rockwell)					
Annealed	E80	E60	—	B95[c]	—
Cold Worked	E100	E95	C37–C47	C22–27[c]	—
FABRICATING PROPERTIES					
Workability	Easily cold worked	Easily cold worked	Must be hot worked except fine wire	Thin sheet and wire can be cold worked, heavier material hot worked	Hot worked at 750–1800 F
Annealing Temp, F	1950 in vacuum	1950 in vacuum	1830 in protective atm	Anneal to specified mechanical properties	1400–2100 in vacuum[f]
Machinability	Like cold rolled steel, with proper lubricants	Like cold rolled steel, with proper lubricants	Difficult, even with special tools and methods; grinding recommended	Like cast iron, but tool life is shorter	Difficult because of low ductility
Joining	Weldable to itself and other metals by resistance or inert arc welding. Special methods necessary	Weldable to itself and other metals by resistance or inert arc welding. Special methods necessary	Weldable to itself by inert arc with special methods; to other metals by brazing or resistance welding	Thin sheet can be resistance welded, heavier sections inert arc welded with special methods. Can be brazed to other metals	Brazed with aluminum alloy or silver alloy rods; not suitable for resistance welding
CORROSION RESISTANCE	Res to most acids (except hydrofluoric); res to most liquid metals. Less res to alkalis	More res than columbium to acids (except hydrofluoric); res to most liquid metals, metallic salts and compounds. Less res to alkalis	Res most acids and alkalis to 212 F, attacked by nitric-hydrofluoric mixture at rm temp, by aqua regia at 212 F	Moderately res to acids and alkalis up to 212 F, attacked by nitric-hydrofluoric mixture at rm temp, by aqua regia at 212 F	Res to air at ambient temp; attacked by both oxygen and nitrogen at elevated temp; res to sea water; rate of attack in fresh water varies with air content
AVAILABLE FORMS	Bar, rod, wire, sheet, foil, tubing, powder, fabricated parts	Bar, rod, wire, sheet, foil, tubing, powder, fabricated parts	Bar, rod, wire, sheet, powder, fabricated parts	Bar, rod, wire, sheet, tubing, powder, fabricated parts	Sheet, plate, rod, bar, tube, powder
USES	Nuclear reactors, missles, rockets, chemical plant equipment, electronic tubes	Capacitors, chemical plant equipment, electronic tubes, rectifiers, surgical implants, nuclear reactors, missiles, rockets, aircraft	Lamp filaments, electrical contacts, nuclear reactors, rockets, missiles, aircraft, radiation shields, electronic tube parts, x-ray targets	Glass melting electrodes, electronic tube parts, furnace heating elements, electrical contacts, aircraft, missile and rocket structures, guidance systems	Nuclear reactors, missles, aircraft

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[a] 32–1832 F. [b] 32 F. [c] From powder. [d] Arc melted.
[e] Warm extruded and annealed at 1400 F. The mechanical properties of beryllium are greatly influenced by the method of fabrication.
[f] Depends on form.

Hafnium, Thorium, Uranium, Vanadium, Zirconium—Wrought

Metal ➔	Hafnium	Thorium	Uranium	Vanadium	Zirconium
PHYSICAL PROPERTIES					
Density, lb/cu in	0.47	0.42	0.69	0.23	0.24
Melting Point, F	3400	3074	2071	3110	3355
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	21.4[a]	14.5[a]	—	9.6
Coef of Ther Exp (70 F), per °F	3.4×10^{-6}	6.2×10^{-6}	12.1×10^{-6}[b]	4.8×10^{-6}	3.1×10^{-6}
Spec Ht, Btu/lb/°F	0.035	0.03	0.03	0.12	0.069
Elec Res (68 F), microhm-cm	30[c]	18	25–50	25	40
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	20×10^6	10×10^6	30×10^6	20×10^6	14×10^6
Ten Str, 1000 psi					
Annealed	—	37.5	90	72	29[d], 59[e]
Cold Worked	—	—	—	113	82[d], 90[e]
Yld Str, 1000 psi					
Annealed	—	27	25	64	11[d], 38[e]
Cold Worked	—	—	—	109	58[d], 84[e]
Elong (in 2 in.), %					
Annealed	—	40	13	28	26[d], 27[e]
Cold Worked	—	—	—	3	1.5[d], 10[e]
Hardness (Rockwell)					
Annealed	B78[f]	—	—	B81	B42[d], B91[e]
Cold Worked	—	—	—	B93	B87[d], B98[e]
FABRICATING PROPERTIES					
Annealing Temperature, F	1380 in vacuum or inert atm	—	—	1650 in vacuum or inert atm	1550; heavy sections in air, light sections in vacuum or inert atm
Workability	Can be hot worked at 1550 F; cold worked 30% between anneals	Can be readily hot or cold worked. Fabricated by forging, rolling, swaging, extruding or drawing	Can be forged, rolled, swaged and drawn. Heating must be done in a protective atm	Good cold working properties	Similar to titanium
Machinability	Similar to stainless steel	Can be machined like mild steel with or without cutting fluids	Moderately difficult to machine	Tools similar to those for cold rolled steel	Similar to titanium
Joining	—	Difficult to weld. Brazing yields brittle joints	Can be welded or brazed in protective atm or vacuum	Can be welded with heliarc torch under argon	Can be arc or flash-butt welded under inert atm
CORROSION RESISTANCE	Resistant to oxidizing acids but attacked by hydrofluoric acid	Very poor resistance to atmosphere, water and most reagents	Very poor resistance to atmosphere, water and most reagents	Resistant to sea water. Not affected by moderate concentration of hydrochloric and sulfuric acids. Dissolved by nitric acid of any strength	Excellent resistance to hydrochloric acid in all concentrations. Resists dilute sulfuric acid, nitric acid in all concentrations, and alkalis. Attacked by aqua regia
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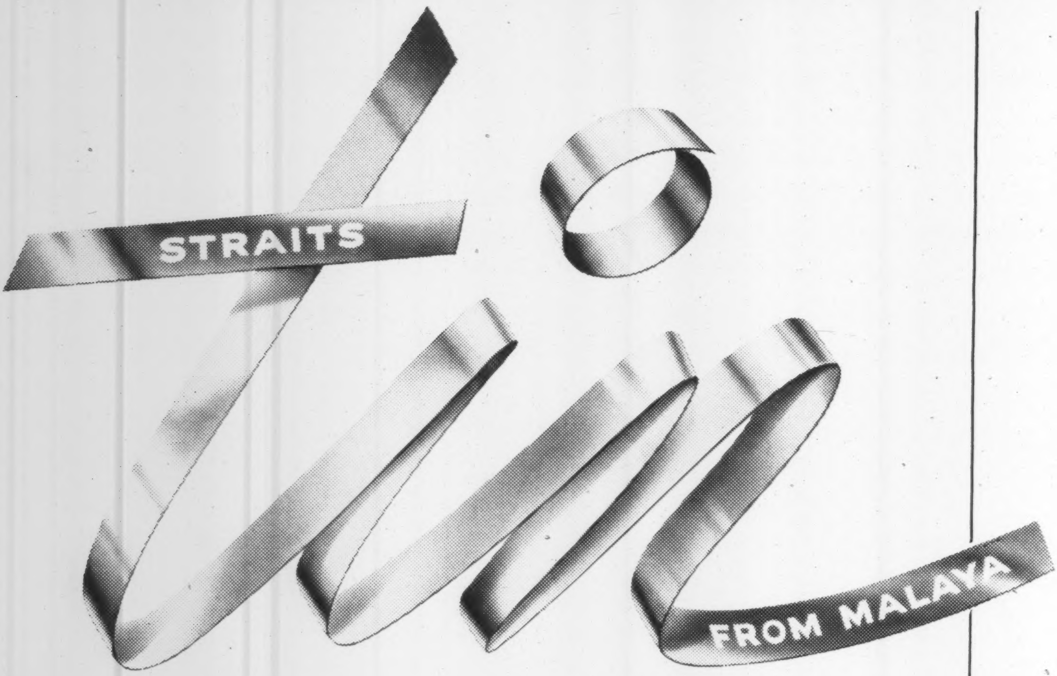
USES	Nuclear reactors	Secondary (breeder) reactor fuel	Fissionable material (fuel) in nuclear reactor	AEC classified applications	Structural parts and fuel cladding in nuclear reactors. Probable future use: corrosion resisting equipment

[a] 70 F. [b] 70–250 F, parallel to A axis; 0.8×10^{-6} parallel to B axis; 12.9×10^{-6} parallel to C axis.

[c] 32 F. [d] Iodide zirconium; cold worked values are for 90% cold worked.

[e] Kroll zirconium, melted in graphite; cold worked values are for 60% cold worked. [f] As-deposited iodide hafnium.



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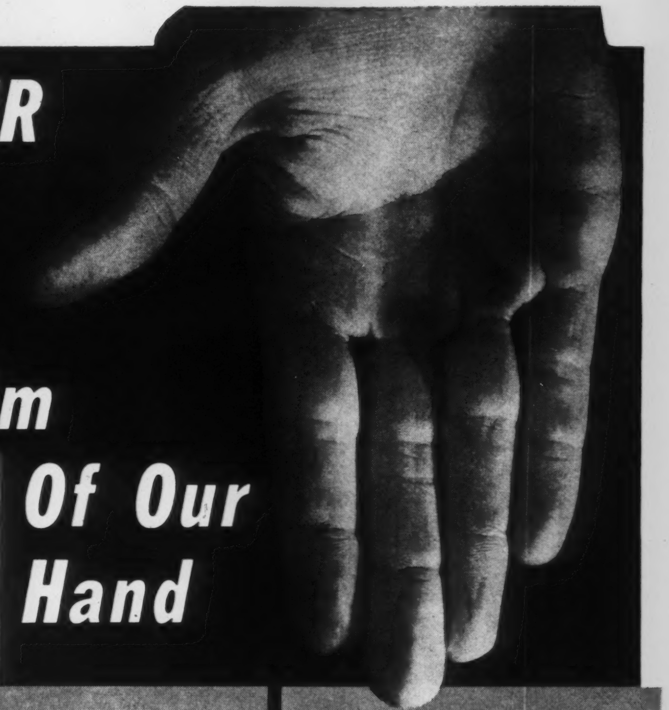

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—Ni 12%—Zn 23%

WRM ALLOY A-15
Nom. Comp. Cu 65%
—Ni 15%—Zn 20%

WRM ALLOY A-10
ASTM Spec. B122—
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Nom. Comp. Cu 66%
—Ni 10%—Zn 24%

WRM ALLOY A-5
Nom. Comp. Cu 65%
—Ni 5%—Zn Balance

WRM ALLOY B-18-S
ASTM Spec. B122—
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Nom. Comp. Cu 55%
—Ni 18%—Zn 27%

WRM ALLOY B-12-S
ASTM Spec. B 122—
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Nom. Comp.
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WRM ALLOY K-12
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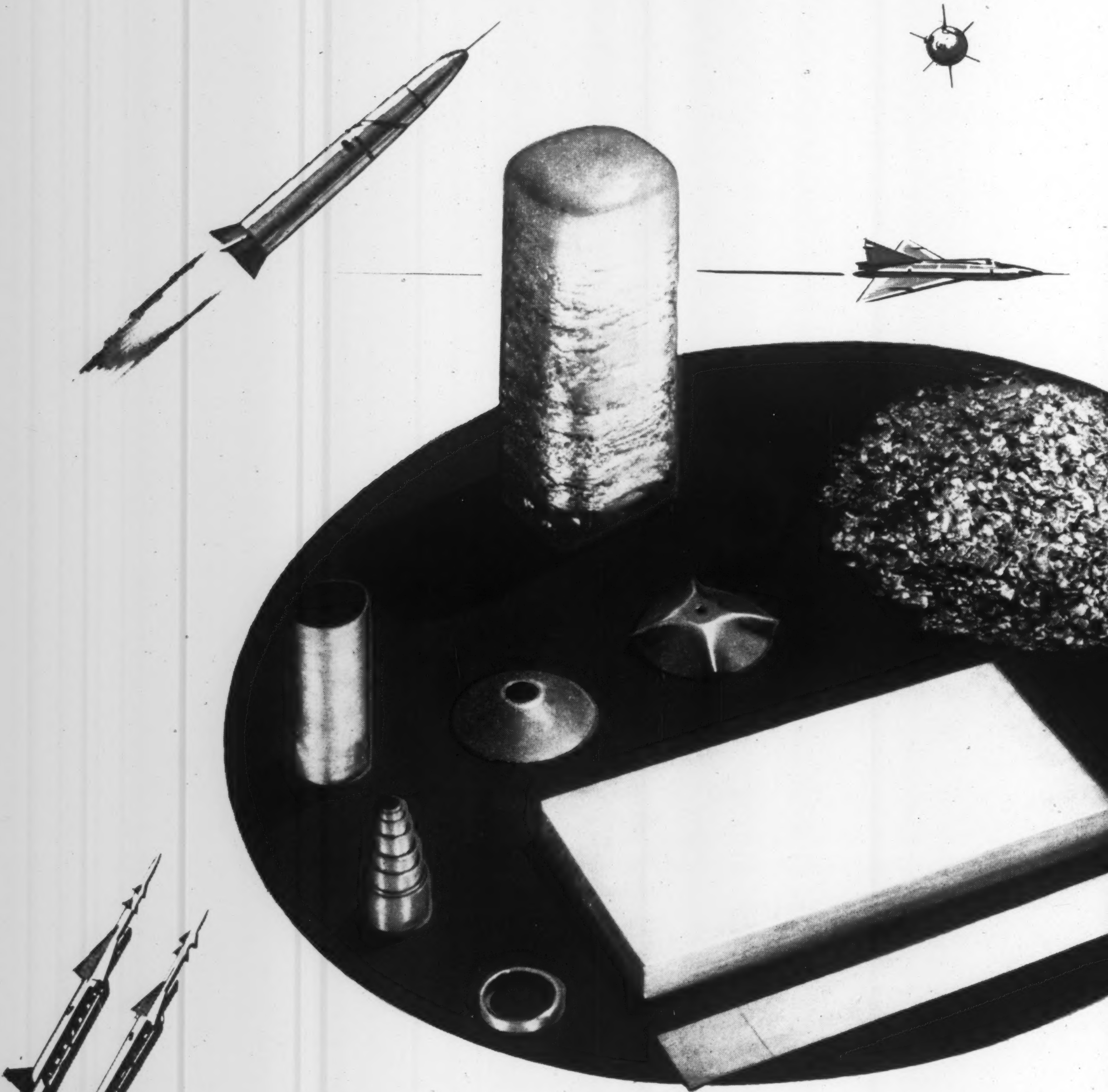
NEW METALS answer tough design



problems

Modern metallurgy is doing much to help designers who are faced with nagging problems of the space age. Performance at excessively high and low temperatures, in severe corrosion and under many other tough operating conditions is now possible with the new metals coming from industry's research laboratories. Union Carbide Metals Company has played a major part in the development of these metals, some of which are described here briefly for you.

Cr **Chromium**—Opening promising avenues of applications as a structural material is ductile chromium. It is extremely resistant to corrosion and to oxidation, with excellent strength up to 1000 deg. F. The first successful extrusion of this pure metal into tubing has been accomplished, as has extrusion into rods and flat stock.

Cb **Columbium**—One of the most exciting metals for the design engineer to consider. Recent advances in production techniques assure adequate supplies of this strong, heat- and corrosion-resistant metal. Its properties make columbium an excellent material of construction in the atomic energy field. New alloys give promise as high-temperature materials for aircraft, missiles and automotive gas turbines.

Ta **Tantalum**—Used in ever-increasing quantities in electronic components and as a corrosion-resistant alloy. Greater production and a variety of mill forms have opened the way for new applications in fast neutron reactors, chemical and pharmaceutical equipment requiring high resistance to acids, alkalies and salts.

Ti **Titanium**—Light, strong, heat- and corrosion-resistant, titanium is rapidly "coming of age." Recent comprehensive laboratory tests and on-the-job performance confirm its superiority for many uses in chemical processing equipment. Much is now known about economical forming, machining and fabricating of this versatile metal. Alloying with noble metals further improves its corrosion resistance. It is providing important advantages for aircraft components and for rotating and reciprocating parts.

W **Tungsten**—Recent advances in fabrication techniques for the reactive metals have brought tungsten metal into prominence for parts of virtually all kinds, particularly where extremely high temperatures are factors. Tungsten has the highest melting point of all metals.

V **Vanadium**—As with others of the reactive metals group, vanadium's ductility improves as impurities are decreased. ELECTROMET vanadium—99.8% pure—"works" much like steel. It can be welded. It is resistant to reducing acids and salt water, and retains good strength to 1500 deg. F. These and other properties make it highly useful as a structural material in the atomic energy field where it does not form brittle alloys with uranium fuel alloy and resists the corrosion of liquid-sodium coolant. Has moderately low neutron capture cross-section.

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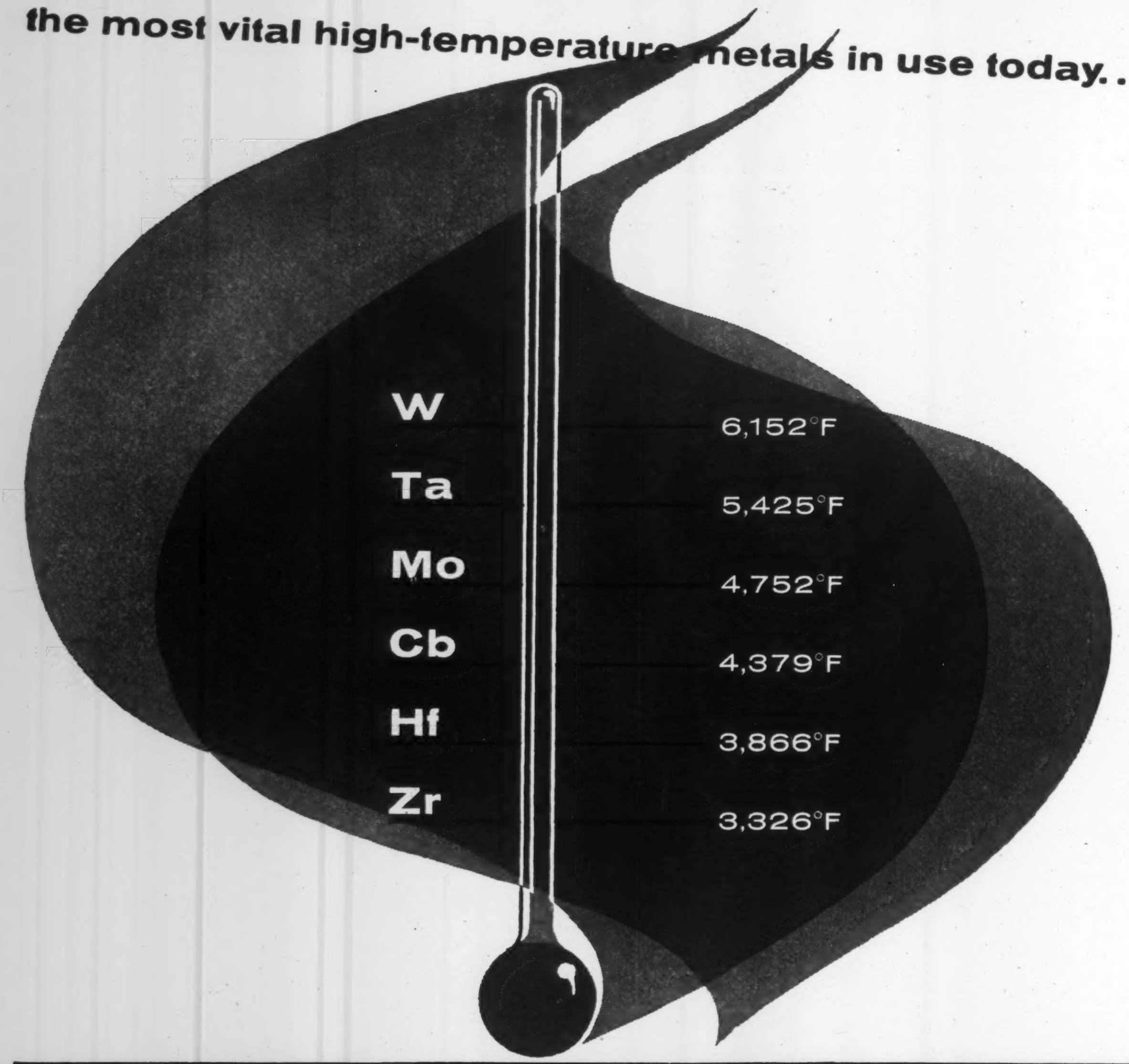

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LITHIUM MATERIALS SELECTOR

PRODUCT	PROPERTIES	APPLICATIONS
LCApplicator	Constructed of high density, high strength graphite rod pressure molded at 1550°C. Unreactive to molten copper. Will not pollute melts nor foul with molten metal.	**Metallurgy:** Inoculator of metal melts with lithium copper cartridges. Two sizes accommodate cartridge and/or cup. Melt range: 50 to 5,560 lbs.
Lithium Metal Cartridges	Form: Lithium metal rod hermetically-sealed in deep drawn copper tubing by "Compression-Spin" process. 2.25 (0.005#), 4.50 (0.010#), & 9.0 (0.020#) gram charges, plus 108 gram copper cup (0.238#).	**Metallurgy:** Deoxidizer and general purifying agent for copper-base alloys. Production of high-conductivity copper castings.
Lithium Chloride **LiCl** **Grade: Technical, Anhydrous salt and 40% solution**	Molecular weight: 42.40. Color and form: white, hygroscopic, granular powder. Density: 2.068 gm/cm³ at 25°C. Melting point: 608°C. Boiling point: 1382°C. Specific heat: 0.288 cal/gm/°C. at 25°C. Heat of formation: -97.70 kcal/mole at 25°C. Heat of solution: -8.49 kcal/mole at 18°C. (200 moles H_2O/mole LiCl). Solubility: Moderately soluble in organic solvents such as alcohols, aldehydes, ketones, esters, pyridine, ethylenediamine, etc. Solubility in water: 40.8 wt. % @ 0°C., 45.4 wt. % @ 20°C., 56.3 wt. % @ 100°C.	**Metallurgy:** Flux component for brazing Al, Mg, Zr, Ti and their alloys. Electrolytic preparation of lithium and other metals. Component of salt bath for heat treating. **Atomic Energy:** Removal of fission products. **Dry Cells:** Used in the aqueous electrolyte which functions at temperatures as low as -60°F. **Aviation:** Preparation of de-icing solutions for parked aircraft in Arctic areas.
Lithium Fluoride **LiF** **Grade: Technical**	Molecular weight: 25.94. Color and form: white powder. Density: 2.639 gm/cm³ at 25°C. Melting point: 848°C. Boiling point: 1681°C. Specific heat: 0.386 cal/gm/°C. at 25°C. Heat of formation: -146.3 kcal/mole at 25°C. Solubility in water: 0.133 wt. % LiF at 25°C.	**Welding:** Used as a component of brazing fluxes and welding rod coatings. Its great affinity for aluminum and magnesium oxides, together with its high fluxing power, has made it a required ingredient. **Glass:** Fluxing agent in corrosion-resistant glass linings and low melting glasses for coating light metals.
Lithium Hydride **LiH**	Purity: The LiH assay, based on the hydrogen yield on reaction with H_2O, ranges from 93% to 98% depending on particle size. Molecular weight: 7.948. Color and form: gray-white to blue; translucent, crystalline mass; brittle. Density: 0.78 gm/cm³ at 20°C. Decomposition pressure: nil at 25°C., 0.07mm. at 500°C., 760mm. at approx. 850°C. Melting point: 684°C. Specific heat: 1.03 cal/gm/°C. at 20°C. Heat of formation: -21.34. kcal/mole at 25°C. Solubility: quite insoluble in nonreactive solvents. Trace solubility reported in polar organic solvents, such as ether.	**Metallurgy:** Cited as a desulfurizing agent for iron and steel. **High Energy Fuels:** Starting material for the manufacture of decaborane ($B_{10}H_{14}$). **Chemical Manufacture:** Manufacture of lithium aluminum hydride and lithium borohydride. Pressurizing Fuel Tanks. **Nuclear Energy:** Radiation shielding against thermal neutrons. **Hydrogen Generation:** One lb. LiH reacts to generate approx. 45 cu. ft. of hydrogen.
Lithium Metal **Li** **Purity: Li content 99.9%** **Lithium Metal** **(Low Sodium Content) 0.005% Na Max.**	Atomic weight: 6.940. Color: silver-white. Density: 0.534 gm/cm³ at 20°C. Melting point: 180.5°C., 356.9°F. Boiling point: 1317°C., 2403°F. Hardness, Mohs' scale: 0.6. Vapor pressure: nil at 20°C., 12mm. at 900°C., 760 mm. at 1317°C. Heat of fusion: 103 cal/gm. Heat of vaporization: 4680 cal/gm. at 1317°C. Specific heat: 0.852 cal/gm/°C. at 25°C., 0.991 cal/gm/°C. at 180°C. (c), 1.047 cal/gm/°C. at 180°C. (1).	**Metallurgy:** Custom, light weight alloys of aluminum-lithium, magnesium-lithium, and magnesium-lithium-aluminum. Self-fluxing brazing alloys of lithium-silver and lithium-silver-copper. Deoxidizer, desulfurizer and degasifier in aluminum die castings, copper, copper-base, bronze and bearing alloys, precious metals (gold). Brazing flux for titanium and zirconium. **Nucleonics:** Fusion reactions. Heat transfer agent.
Lithium Nitrate **$LiNO_3$** **Grade: Technical**	Molecular weight: 68.95. Li_2O content: 21.7%. Color and form: white, hygroscopic, crystalline powder. Density: 2.366 gm/cm³ at 20°C. Melting point: 251.4°C. Decomposition temperature: 600°C. Specific heat: 0.387 cal/gm/°C. at 210°C. Heat of formation: -115.279 kcal/mole at 25°C. Heat of solution: -0.333 kcal/mole at 18°C. (200 moles H_2O/mole $LiNO_3$). Solubility in water: 43.3 wt. % $LiNO_3$ at 20°C.	**Metallurgy:** Salt baths. Phosphate coating of metals; lowered acidity and increased rate of reaction without affecting color or structure of coating. **High Energy Fuels:** Oxidizing agent for use in solid propellant combinations for rockets. **Nucleonics:** Heat exchange media. **Pyrotechnics:** Used in signal flares and fireworks.
Lithium Perchlorate **$LiClO_4$** **Grade: Technical**	Molecular weight: 106.40. Color and form: white, crystalline powder. Density: 2.43 gm/cm³ at 25°C. Melting point: 248°C. Decomposition starts at about 400°C. and becomes rapid at about 430°C., forming LiCl and oxygen. High content of available oxygen (60% by weight). Heat of formation: -91.8 kcal/mole at 25°C. Solubility in water: 29.9 wt. % $LiClO_4$ at 0°C., 37.5 wt. % $LiClO_4$ at 25°C., 71.5 wt. % $LiClO_4$ at 100°C.	**Oxidizing Agent:** Contains 60 wt. % available oxygen (as compared to 46 wt. % for $KClO_4$ and 25 wt. % for NH_4ClO_4). $LiClO_4$ contains more oxygen per unit volume than liquid oxygen.

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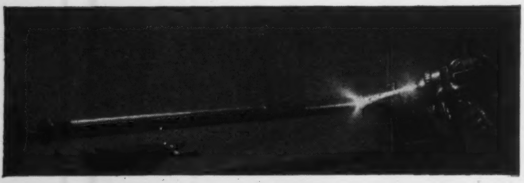

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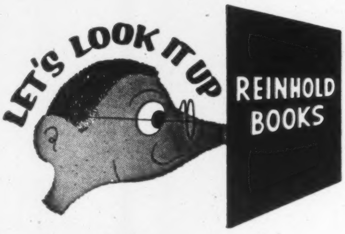

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ALLOY	Temper	Properties				
		Tensile Strength Psi	Elong. % in 2 in.	Tensile Strength Psi	Elong. % in 2 in.	Elec. Cond. % IACS
25	Annealed	60- 78,000	35-60	165-190,000	4-10	22-25
	Hard	100-120,000	2- 8	190-215,000	1- 4	22-25
165	Annealed	60- 78,000	35-60	150-180,000	4-10	22-25
	Hard	100-120,000	2- 8	180-200,000	1- 4	22-25
10	Annealed	35- 55,000	20-35	100-110,000	8-12	48-55
	Hard	70- 85,000	5-10	110-125,000	5- 8	48-52
35	Annealed	35- 55,000	20-35	100-110,000	8-12	48-55
	Hard	70- 85,000	5-10	110-125,000	5- 8	48-52
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Tensile Strength (psi)	18,000	4,000
Modulus of Rupture (psi)	35,000	14,000
Modulus of Elasticity (psi x 10^6)	45	20
Specific Heat (BTU/lb./°F.)	0.24	0.57
Thermal Conductivity (BTU/hr./ft.^{2}/°F./ft.)	125	9.7
Resistivity of low density BeO (Ohm-cm. x 10^6)	7000	4
Specific Gravity	3.008	
Melting Point (°F.)	4658	
Coefficient of Expansion (in/in/°F. x 10^{-6}) R.T.–500°F. R.T.–2200°F.	4.4 6.2	
Thermal Shock Resistance	Excellent	
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Loss Factor (10^7 cps)	0.0004	

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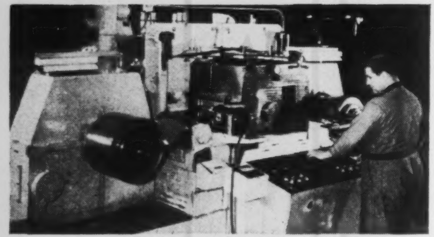

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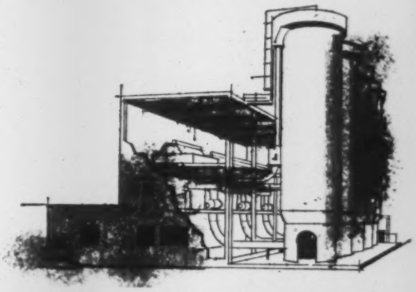

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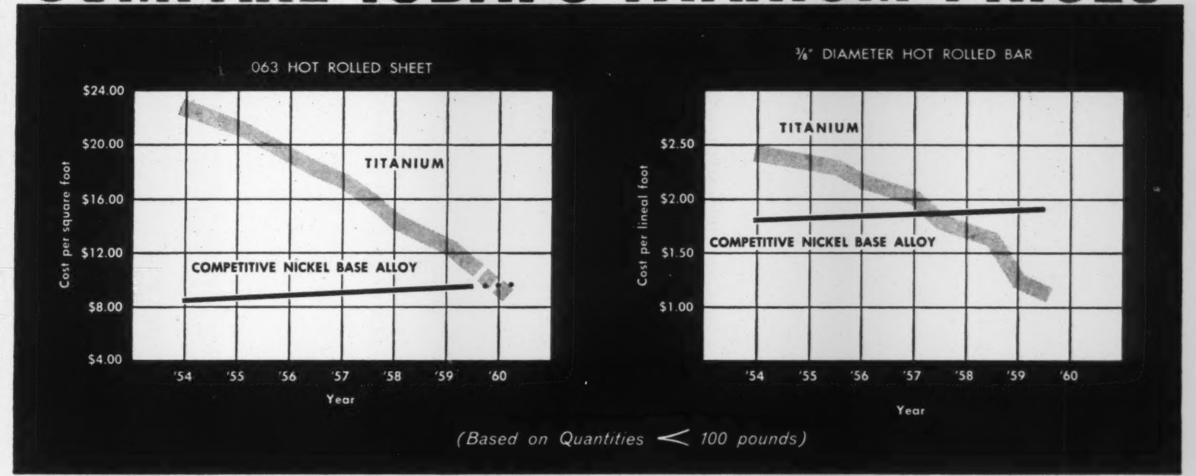

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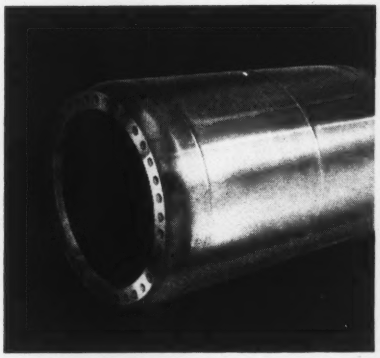

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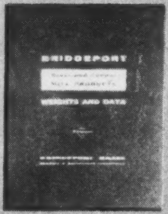
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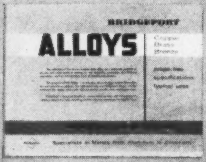
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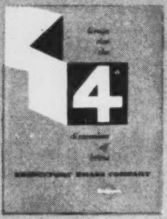
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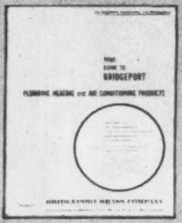
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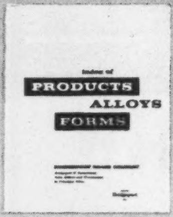
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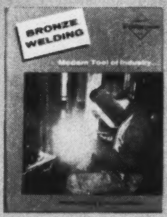
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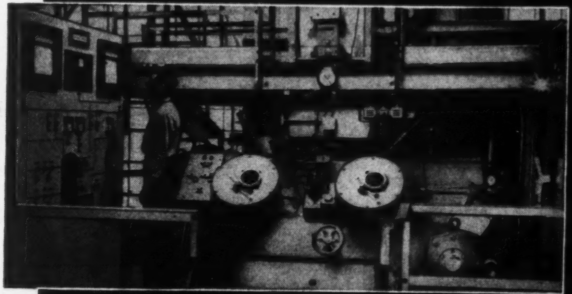

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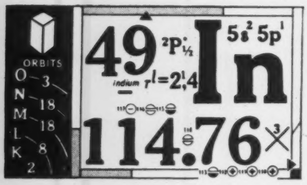

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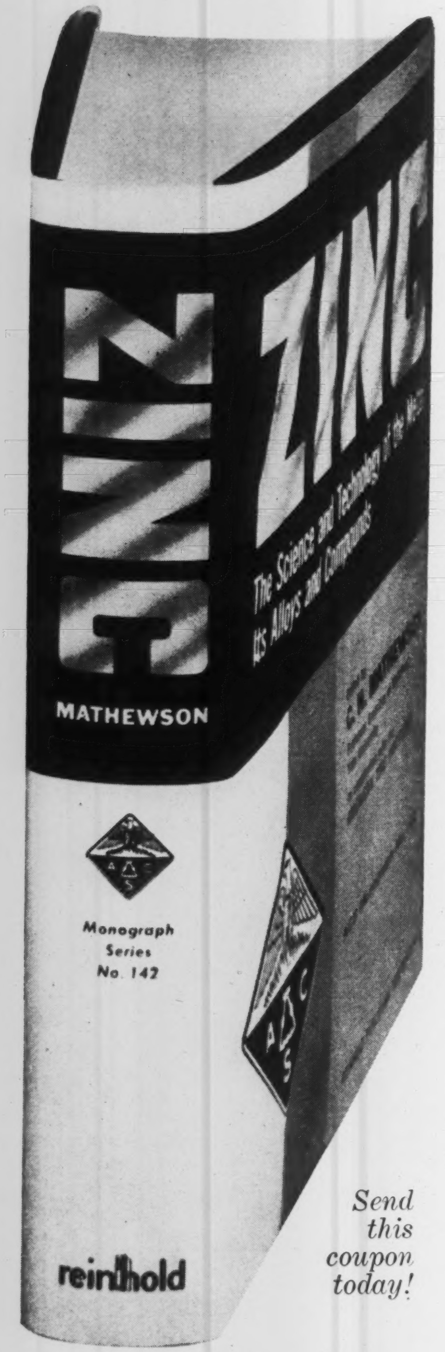
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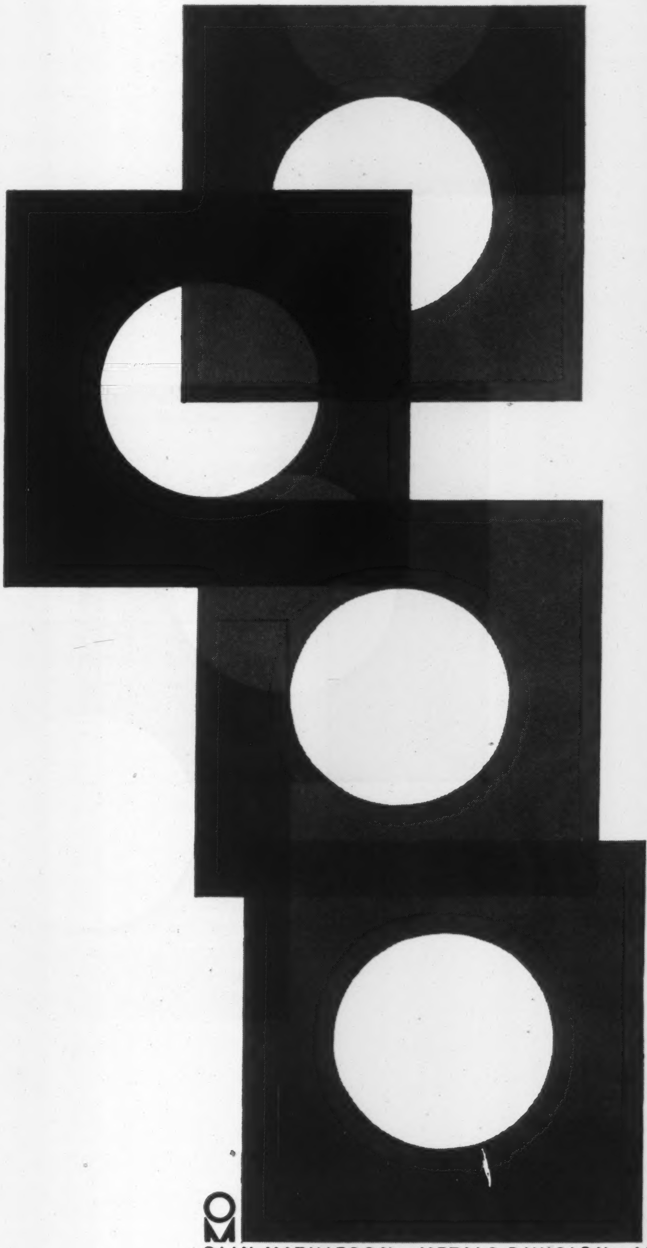

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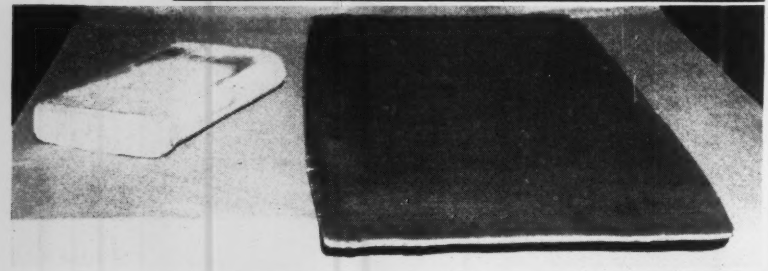

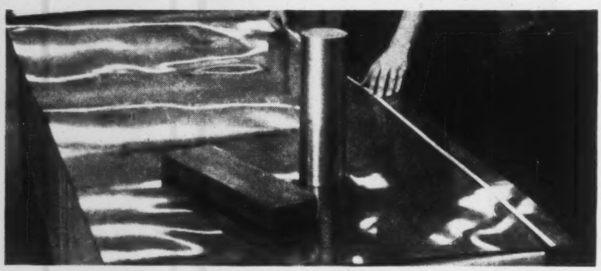

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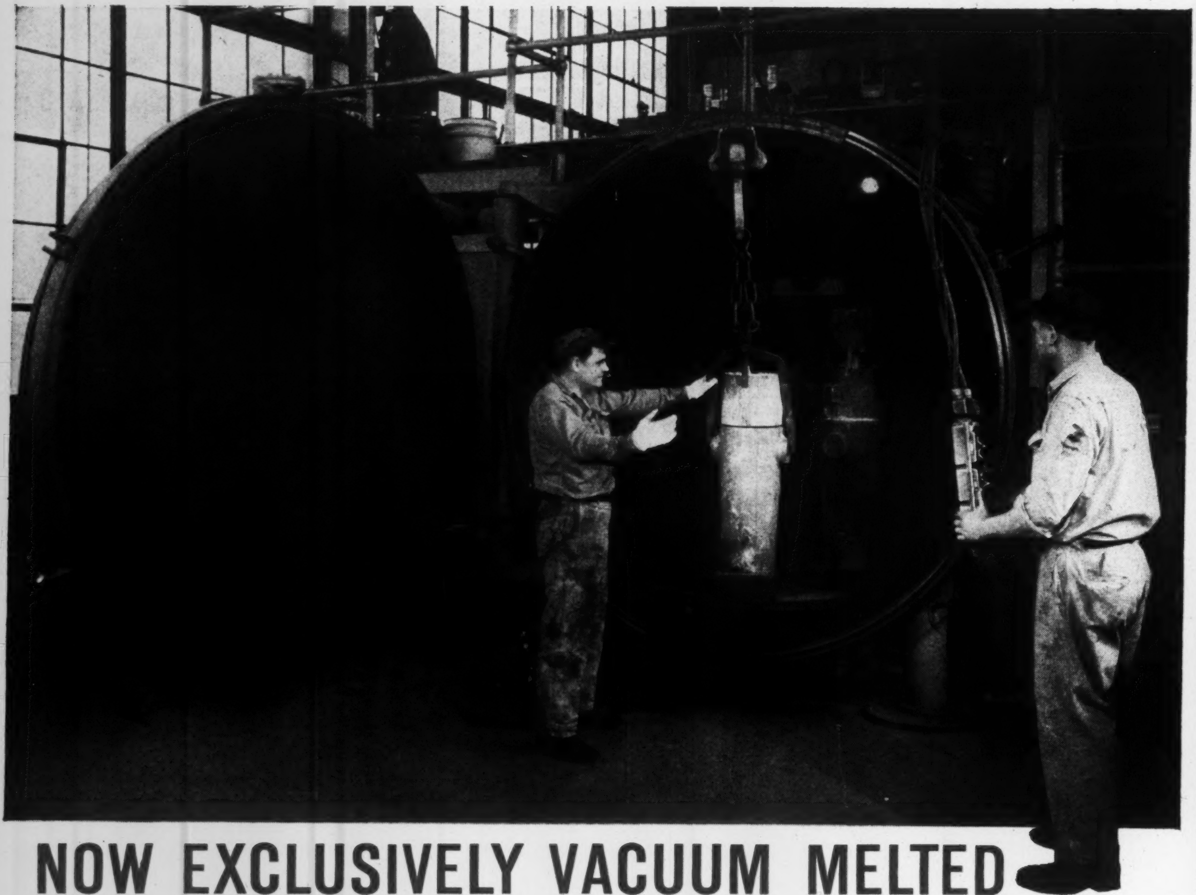

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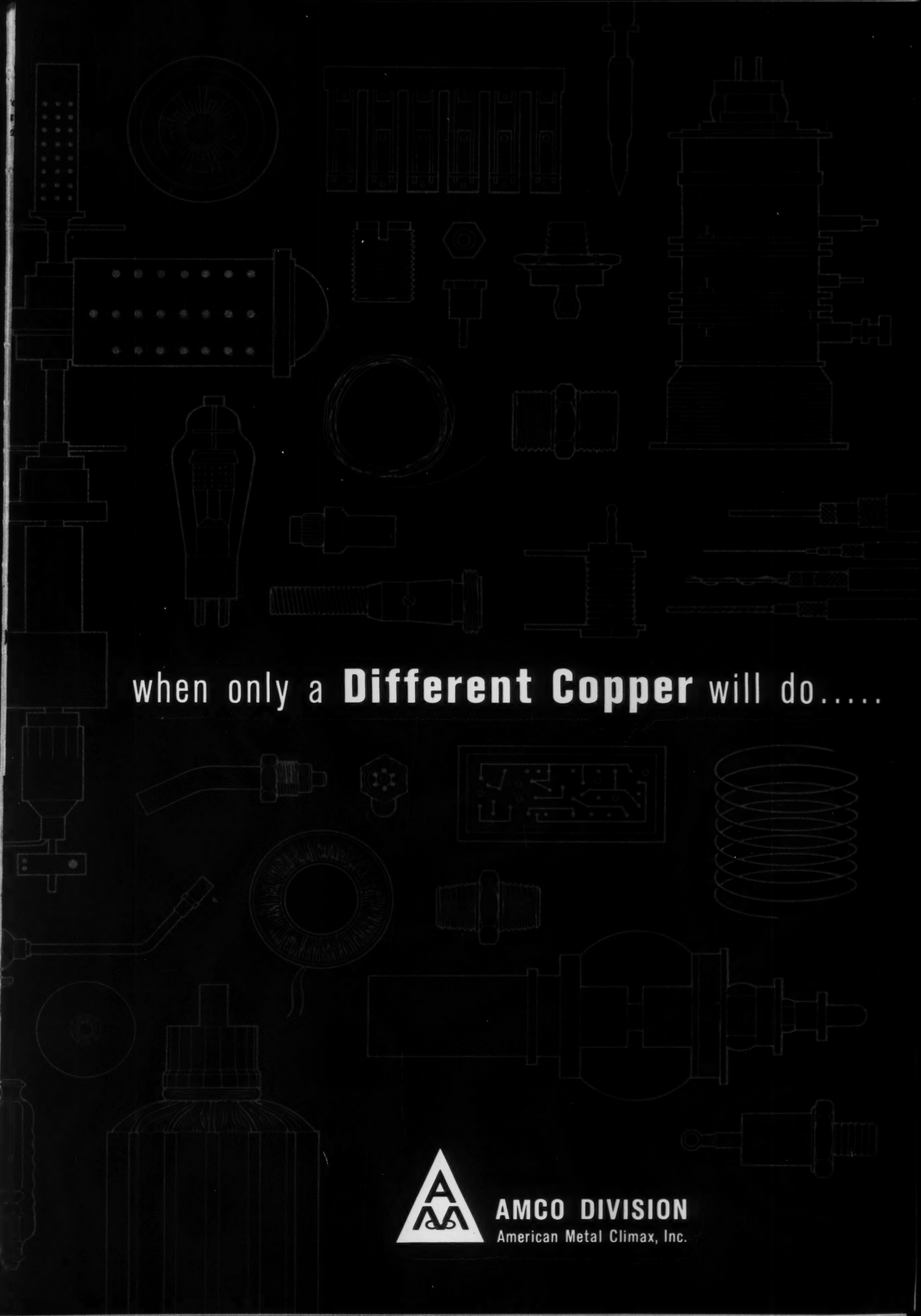
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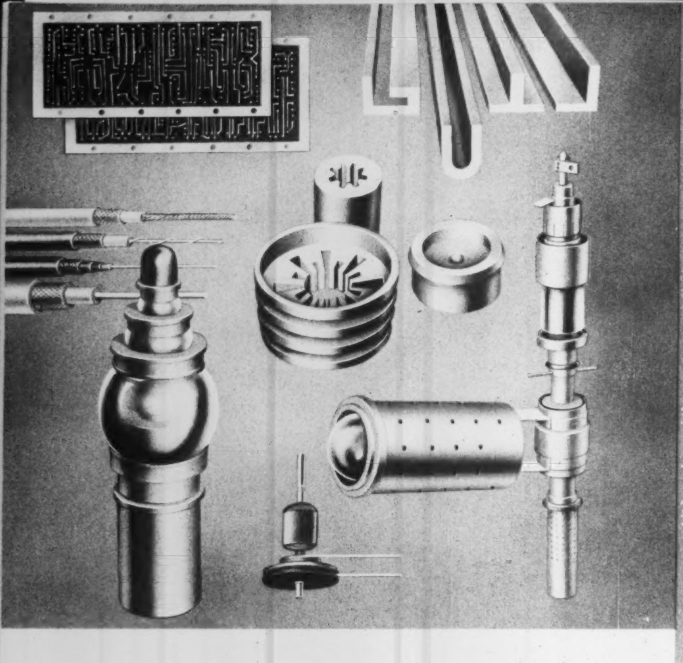

OFHC®

When you need conductivity of 101.5% IACS plus good formability at high strength levels

DISTINCTIVE CHARACTERISTICS: Totally free of oxides and residual deoxidizers, OFHC is 99.99% pure copper. For more than 20 years it has been recognized as the *one* copper able to meet all demands for precision electronic and electrical applications. OFHC offers high conductivity . . . excellent hot and cold workability . . . immunity to hydrogen embrittlement . . . soundness and high density to assure total vacuum . . . low volatility under high vacuum . . . adherent oxide scale . . . superior anodic action in electroplating.

APPLICATIONS: OFHC is the preferred copper for essential parts of electronic components such as high-frequency oscillators . . . magnetrons . . . triodes . . . tubes requiring glass-to-metal seals. Rotary components of power-generating equipment and other items requiring the highest obtainable electrical and thermal conductivity rely on OFHC.

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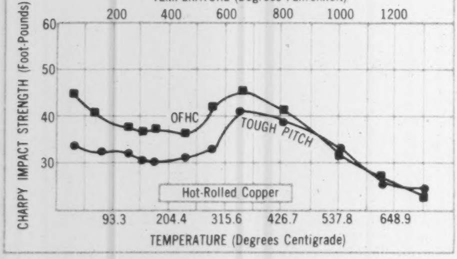

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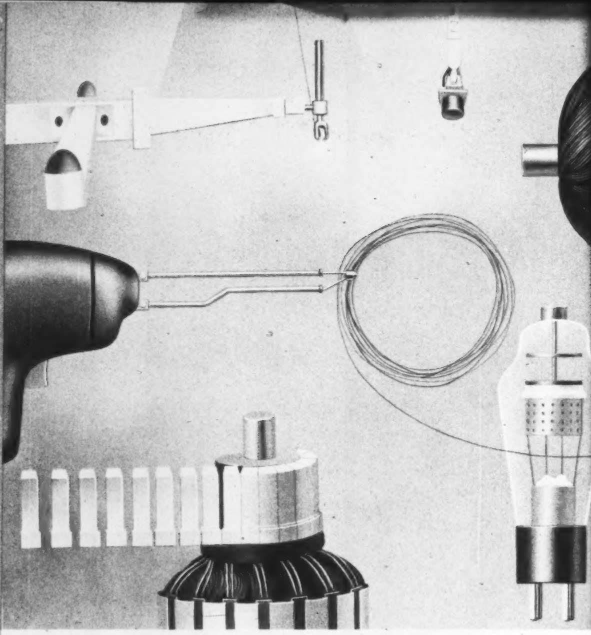


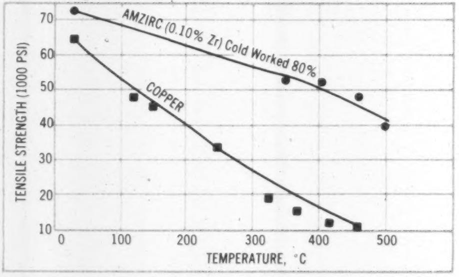
AMZIRC®

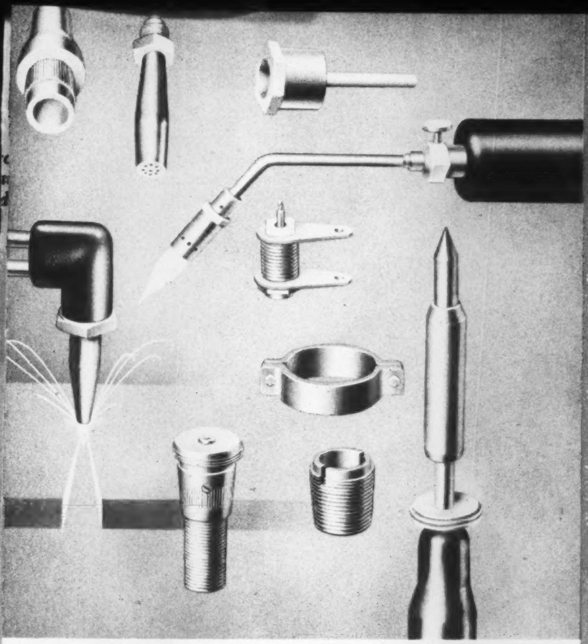
When you need tensile strength of up to 52,000 psi at 400°C plus conductivity of 95% IACS

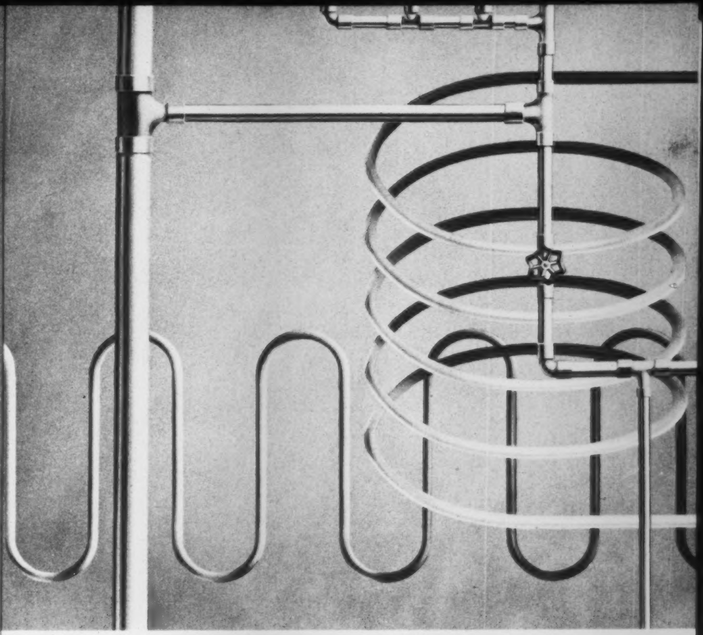
DISTINCTIVE CHARACTERISTICS: AMZIRC consists of OFHC Copper and a rigidly controlled addition of high-purity Zirconium. The designer will find in AMZIRC high conductivity . . . retention of strength at elevated temperatures where copper and conventional high-conductivity alloys weaken . . . extreme notch toughness . . . transverse properties equal to longitudinal properties . . . hardness . . . exceptional hot and cold workability.

APPLICATIONS: Typical of the many products that have been improved or made possible by AMZIRC's unique combination of characteristics are high-temperature magnet wire . . . commutators and collector rings . . . rotor wedges . . . resistance welding wheels and tips . . . electron tube studs and side rods . . . rectifier bases.

TENSILE STRENGTH vs TEMPERATURE







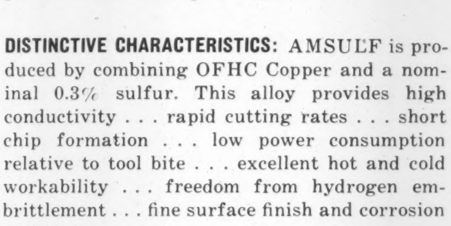
AMSULF®

When you need machinability rating of 90 and good workability, plus conductivity of 96% IACS

DISTINCTIVE CHARACTERISTICS: AMSULF is produced by combining OFHC Copper and a nominal 0.3% sulfur. This alloy provides high conductivity . . . rapid cutting rates . . . short chip formation . . . low power consumption relative to tool bite . . . excellent hot and cold workability . . . freedom from hydrogen embrittlement . . . fine surface finish and corrosion resistance.

APPLICATIONS: AMSULF is ideal for machined parts, especially automatic screw machine products. Its hot and cold workability and immunity to hydrogen embrittlement allow fabricating and finishing techniques impossible with conventional free-cutting coppers. Representative of the parts now being produced from AMSULF are flame-cutting nozzles . . . parts for motors and switches . . . electrical connectors, clamps, and clips . . . soldering iron tips . . . studs and terminals.

RELATIONSHIP OF ELONGATION, REDUCTION OF AREA, AND TENSILE STRENGTH



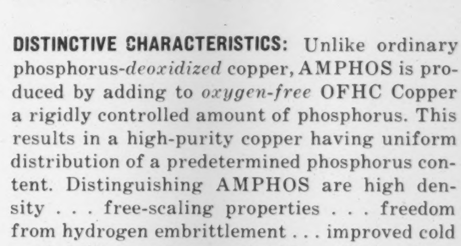
AMPHOS®

When you need exceptional hot and cold workability plus rapid piercing and drawing rates

DISTINCTIVE CHARACTERISTICS: Unlike ordinary phosphorus-*deoxidized* copper, AMPHOS is produced by adding to *oxygen-free* OFHC Copper a rigidly controlled amount of phosphorus. This results in a high-purity copper having uniform distribution of a predetermined phosphorus content. Distinguishing AMPHOS are high density . . . free-scaling properties . . . freedom from hydrogen embrittlement . . . improved cold workability . . . absence of voids . . . high softening temperature.

APPLICATIONS: AMPHOS should be specified for all tube, pipe, and related products where exacting specifications or fabricating techniques result in an appreciable number of rejects when ordinary phosphorized copper is used. Its suitability for welding and brazing and immunity to embrittlement make AMPHOS a superior material for condenser tubes . . . heat exchange units . . . coils . . . complex piping.

SOFTENING TEMPERATURE



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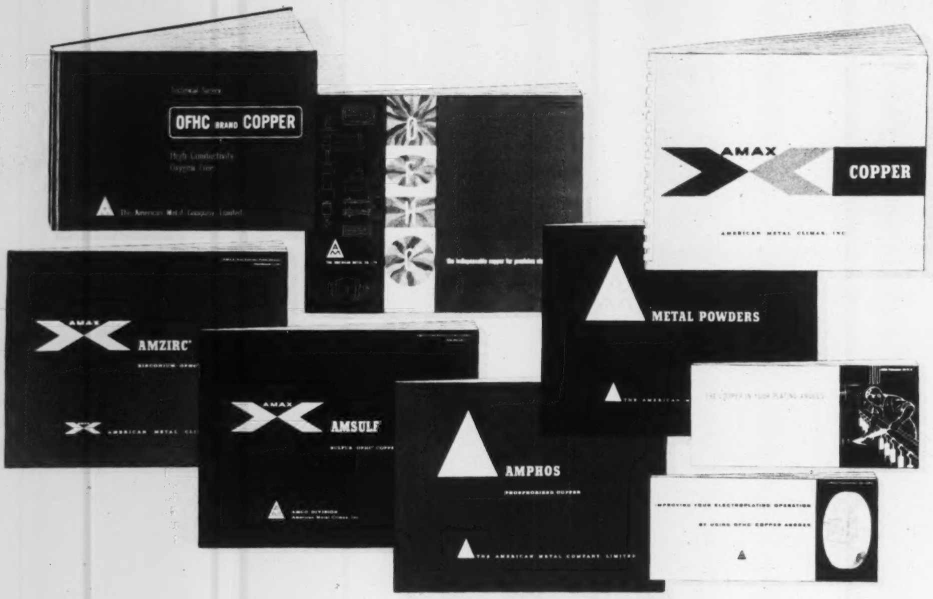
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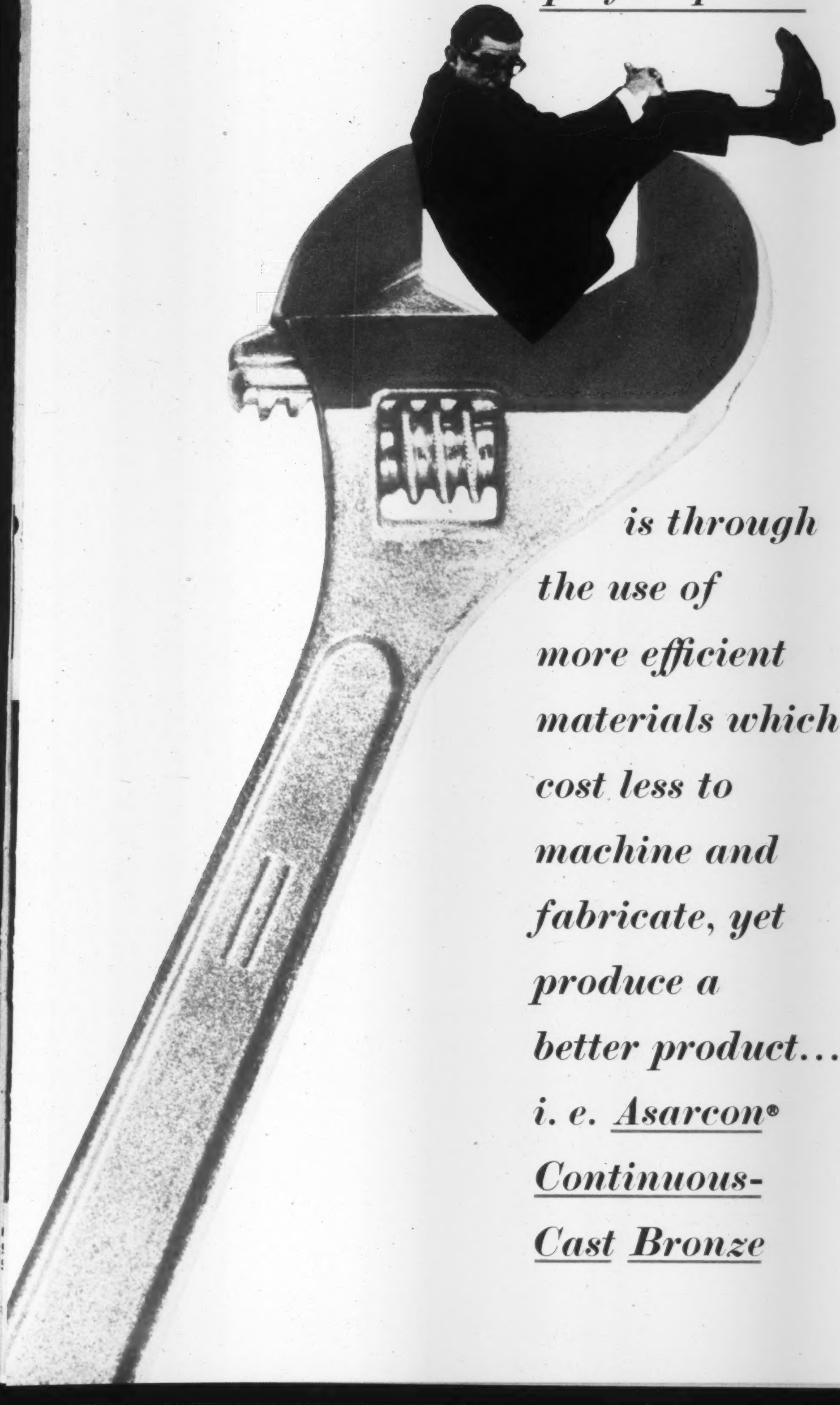

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cost less to
machine and
fabricate, yet
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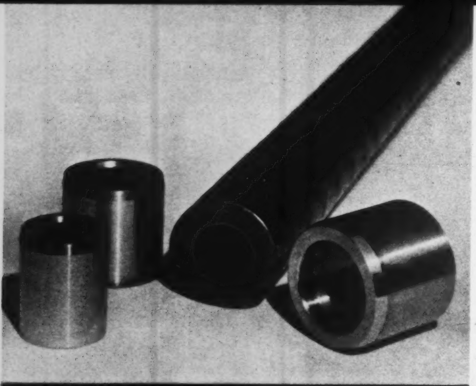

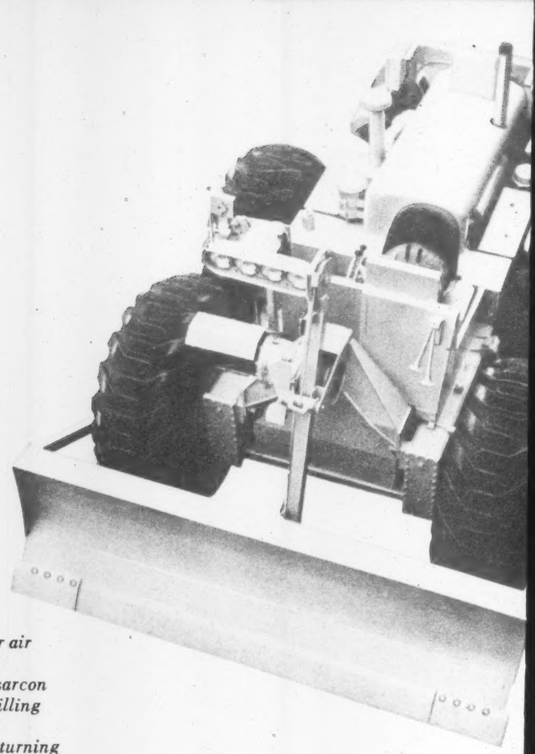

Cushion collars for air cylinders cut from continuous-cast Asarcon tubes eliminate drilling operation, also cut costs of finishing, turning and grinding collars to very close tolerances.

Design for full production efficien

Remington Rand
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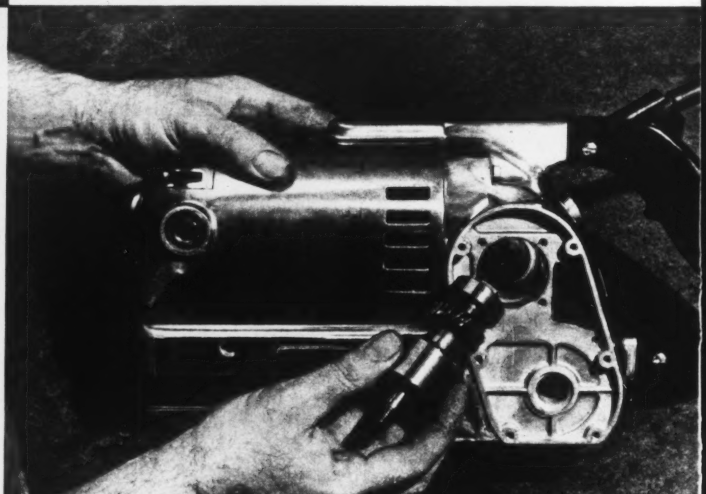
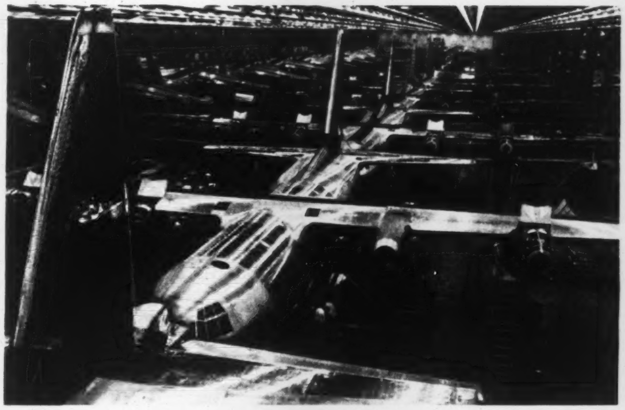
Motor-drive clutch-ratchet shaft bearings in various Remington Rand calculating machines are continuous-cast from Asarcon 773 Bearing Bronze. These bearings test out 33% higher in impact strength to their sand-cast predecessors!



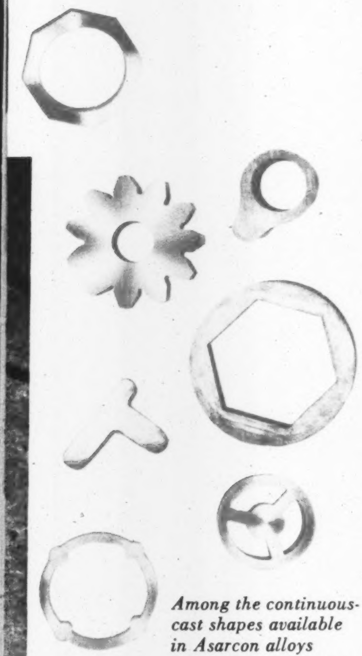
Easy machining and longer wear governed the choice of Asarcon bronze for the worm gears and guide bushings on this power belt sander.

on bronze, as power transmission bearings
vy duty equipment, improves performance,
ds service life.



Asarcon bronze bearings act as seal against 3000 pounds of oil pressure in control assembly in Lockheed's C-130. These bearings save space, weight. Their great uniformity gives low friction, high load capacity.

NTINUOUS-CAST BRONZE CASTINGS



Among the continuous-cast shapes available in Asarcon alloys are those suitable for valve guides, bushings, thrust washers, retainers, gears, brake discs, nozzles, seals, sleeves, plugs.

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Synthetic Rubbers. Texas-U.S. Chemical Co., 260 Madison Ave., New York 16, 60 pp. Specifications, physical and chemical properties, and standard recipes for butadiene-styrene rubbers. Write on company letterhead directly to Texas-U.S. Chemical Co.

Thermal Insulations. H. I. Thompson Fiber Glass Co., 36 pp, illus. Information on a fibrous silica material, molded fiberglass, reinforced plastics and metal blankets used for high and low temperature insulation. **158**

TFE Sheets, Rods. Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., 8 pp, illus. Properties, uses, fabrication and quality control of TFE sheets, rods, tubes, tapes and other standard shapes. **159**

Sponge Rubber. U. S. Rubber Co., Kem-Blo Sponge Div., 4 pp, illus. Applications, dimensions and specifications for various types of sponge rubbers. **160**

Thermoplastic Sheet. United States Rubber Co., Royalite Plastic Products Div., 4 pp, illus. Samples, colors, grains, constructions and types of ABS thermoplastic sheet. **161**

Rubber. Roth Rubber Co., Div. of Vapor Heating Corp., 1860 S. 54 Ave., Chicago, Ill., No. MM3. Actual rubber samples with hardness from 5 to 100 durometer. Write on company letterhead directly to Roth.

Urethane Foams. Witco Chemical Co., Inc., 22 pp, Nos. F-1, 2 and 3. Information on polyester resins for use in the production of flexible and rigid urethane foams. **162**

To get literature, use free post card on p 427, 463 or 545

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Acrylics—Cast, Molded, Extruded

Type ➡		Cast Resin Sheets, Rods		Moldings	
		General Purpose Type I[a]	General Purpose Type II[a]	Grades 5, 6, 8[b]	High Impact Grade
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.18-1.19	1.18-1.19	1.18-1.19	1.12-1.16
Ther Cond, Btu/hr/sq ft/°F/ft	[c]	0.10-0.15	0.10-0.15	0.12	0.12
Coef of Ther Exp, 10^{-5} per °F	D696	5	5	3-4	3
Spec Ht, Btu/lb/°F		0.35	0.35	0.35	0.34
Refractive Index	D542	1.485-1.500	1.485-1.495	1.489-1.493	—
Transmittance (luminous, 0.125 in.), %	D791	91-92	91-92	>92	—
Haze, %	D672	1-2	1-2	<3	—
Water Absorption (24 hr), %	D570	0.3-0.4	0.2-0.4	0.3-0.4	0.3
Flammability (0.125 in.), ipm	D635	0.5-2.5	0.5-2.5	0.9-1.2	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	3.5-4.5	4.0-5.0	3.5-5.0	2.3-3.0
Ten Str, 1000 psi	D638	6-8	8-10	8-10.5	5.5-7.3
Elong (in 2 in.), %	D638	2-7	2-7	3-5	>25
Hardness (Rockwell)	D785	M90-100	M96-102	M80-103	L58-89
Impact Str (Izod notched), ft-lb/in.	D256	0.5	0.4	0.3-0.5	0.8-2.0
Mod of Elast in Flex, 10^5 psi	D790	3.5-4.5	4.0-5.0	3.5-5.0	2.8-3.6
Flex Str, 1000 psi	D790	12-14	15-17	15-16	8.7-11.5
Compr Yld Str (0.1% offset), 1000 psi	D695	10-12	12-14	14.5-17	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	$>10^{15}$	$>10^{15}$	$>10^{14}$-10^{15}	2.0×10^{16}
Dielec Str (short time), v/mil	D149	450-500	450-500	400-500	400-500
Dielec Const					
60 Cycles	D150	3.5-4.5	3.5-4.5	2.2-3.9	3.0-4.0
10^6 Cycles	D150	2.7-3.2	2.7-3.2	2.2-2.9	2.0-3.0
Dissip Factor					
60 Cycles	D150	0.05-0.06	0.05-0.06	—	0.03-0.04
10^6 Cycles	D150	0.02-0.03	0.02-0.03	0.02-0.03	0.01-0.02
Arc Resistance, sec		No track	No track	No track	No track
FABRICATING PROPERTIES					
Bulk Factor		—	—	1.8-2.2	—
Injection Molding					
Pressure, 1000 psi		—	—	15-30	10-20
Temperature, F		—	—	350-475	400-490
Hot Forming Temp, F		250-320	280-340	—	—
Extruding Temp, F		—	—	350-450	—
HEAT RESISTANCE					
Max Rec Svc Temp, F		140-160	180-200	155-190	—
Heat Dist Temp, F		150-170	190-210	166-202[d]	169-174
CHEMICAL RESISTANCE		Resist weak alkalis, acids and aliphatic hydrocarbons. Attacked by esters, ketones, aromatic hydrocarbons, chlorinated hydrocarbons and concentrated acids			
USES		Transparent aircraft enclosures, radio and television parts, lighting, drafting equipment, signs		Decorative and functional automotive parts, reflectors, protective goggle lenses, radio and television parts, household appliance parts	Shoe heels, control knobs, business machine and piano keys, pump parts, sprinkler heads, tool handles

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[a] ASTM D702-46.

[b] Range includes typical values for Grades 5, 6 and 8, and may be superior to minimum or maximum requirements for these grades as detailed in ASTM D788-56T.

[c] Cenco-Fitch.

[d] D788 specified values for Grades 5, 6 and 8: 149 F, 162 F, 183 F respectively.

Alkyds—Molded

Type ➡		General Purpose	Electrical	High Strength
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792	2.22–2.24	2.16–2.18	2.00–2.08
Ther Cond, Btu/hr/sq ft/°F/ft		0.35–0.60	0.35–0.60	0.20–0.30
Coef of Ther Exp, per °F	D696	1–3 x 10^{-5}	1–3 x 10^{-5}	1–3 x 10^{-6}
Water Absorption (24 hr), %	D570	0.08–0.10	0.04–0.06	0.07–0.10
Flammability, ipm		Not self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES				
Tensile Strength, 1000 psi	D651	3–4	3–4	6–10
Impact Strength (Izod notched), ft-lb/in.	D256	0.30–0.35	0.30–0.35	8–12
Mod of Elast in Flexure, psi	D790	22–27 x 10^5	22–27 x 10^5	22–28 x 10^5
Flexural Strength, 1000 psi	D790	7–10	7–10	14–17
Compressive Strength, 1000 psi	D690	16–20	18–20	24–28
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	10^{14}	10^{14}	10^{14}
Dielectric Strength (step by step), v/mil	D149	300–350	300–350	300–350
Dielectric Constant				
60 Cycles	D150	6.0–6.5	6.0–6.5	5.2–6.0
10^6 Cycles	D150	4.8–5.0	4.2–4.5	4.0–4.5
Dissipation Factor				
60 Cycles	D150	0.050–0.060	0.035–0.040	0.02–0.03
10^6 Cycles	D150	0.016–0.018	0.014–0.015	0.017–0.022
FABRICATING PROPERTIES				
Bulk Factor	D954	1.95–2.15	1.85–2.05	9–11
Compression Molding				
Pressure, 1000 psi		1.0–1.5	1.0–1.5	1.5–2.0
Temperature, F		270–330	270–330	270–330
HEAT RESISTANCE				
Max Rec Svc Temp (limited periods), F		350	300	350
Heat Dist Temp (264 psi), F	D648	350–400	350–400	>400
CHEMICAL RESISTANCE		Resistant to weak acids; attacked by alkalis; practically unattacked by organic liquids such as alcohols, hydrocarbons and fatty acids		
USES		Ignition parts, fuse blocks, switch and circuit breaker covers and bases, molded resistors and capacitors, television tuner segments		

Cellulose Acetate—Molded, Extruded

Type ➡		Type I —Medium[a]	Type II—Hard[a]			Type III —Soft[a]
			H6	H4	H2	
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	1.27-1.34	1.29-1.34	1.28-1.34	1.27-1.34	1.27-1.34
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.10-0.19	0.10-0.19	0.10-0.19	0.10-0.19	0.10-0.19
Coef of Ther Exp, 10^{-5} per °F	D696	4.4-9.0	4.4-9.0	4.4-9.0	4.4-9.0	4.4-9.0
Refractive Index	D542	1.46-1.50	1.46-1.50	1.46-1.50	1.46-1.50	1.46-1.50
Spec Ht, Btu/lb/°F		0.3-0.42	0.3-0.42	0.3-0.42	0.3-0.42	0.3-0.42
Transmittance (luminous), %	D791	80-90	75-90	75-90	80-90	80-95
Haze, %	D672	3-10	4-15	4-15	4-10	3-8
Water Absorption (24 hr), %	D570	2.2-5.7	2.0-3.5	1.9-3.6	2.2-5.3	2.3-6.5
Flammability, ipm	D635	0.5-2.0	0.5-2.0	0.5-2.0	0.5-2.0	—
MECHANICAL PROPERTIES						
Ten Str, 1000 psi	D638	2.7-6.5	6-8.5	5.4-7.6	4.6-6.7	1.9-4.7
Elong (in 2 in.), %	D638	18-47	6-31	12-35	17-40	32-50
Hardness (Rockwell)	D785	R72-115	R112-123	R106-121	R101-119	R49-103
Impact Str (Izod notched), ft-lb/in.	D256	1.1-4.0	0.4-1.9	0.6-2.3	0.7-2.7	2.0-5.2
Mod of Elast in Flex, 10^5 psi		1.1-3.5	2.6-4.0	2.3-3.4	1.9-3.3	0.9-2.5
Compr Str, 1000 psi	D695	14.5-25	25-36	22-33	19-28	13-20
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	10^{10}-10^{13}	10^{10}-10^{13}	10^{10}-10^{13}	10^{10}-10^{13}	10^{10}-10^{13}
Dielec Str (short time), v/mil	D149	250-365	250-365	250-365	250-365	250-365
Dielec Const						
60 cycles	D150	3.5-7.5	3.5-7.5	3.5-7.5	3.5-7.5	3.5-7.5
10^6 Cycles	D150	3.2-7.0	3.2-7.0	3.2-7.0	3.2-7.0	3.2-7.0
Dissipation Factor						
60 Cycles	D150	0.03-0.38	0.03-0.38	0.03-0.38	0.03-0.08	0.03-0.08
10^6 Cycles	D150	0.03-0.33	0.03-0.33	0.03-0.33	0.03-0.33	0.03-0.33
FABRICATING PROPERTIES						
Bulk Factor		2.0-2.6	2.0-2.6	2.0-2.6	2.0-2.6	2.0-2.6
Compression Molding						
Pressure, 1000 psi		500-5000	500-5000	500-5000	500-5000	500-5000
Temperature, F		280-350	350-420	330-390	320-370	260-310
Injection Molding						
Pressure, 1000 psi		8-32	8-32	8-32	8-32	8-32
Temperature, F		355-440	420-490	410-480	390-460	335-395
Extruding Temp, F		355-400	420-450	405-455	390-420	335-365
HEAT RESISTANCE		As these are thermoplastic materials, they gradually become softer as the temperature rises. Maximum service temperature depends on such factors as formula, design of part, humidity and service conditions				
CHEMICAL RESISTANCE		Unattacked by water, salt water solutions, white gasoline, oleic acid, 5% acetic acid and dilute sulfuric acid. Decomposed by 30% sulfuric, 10% nitric and 10% hydrochloric acids; sodium hydroxide; and 10% ammonium hydroxide. Dissolved by acetone and ethyl acetate				
USES		Automotive and radio knobs, tool handles, business machine keys. Electrical items such as fluorescent lamp supports, coil spools and contact bases. Toys and novelties, sunglass goggles and frames, spectacle frames, buttons and tags				

[a] ASTM D706-55T.

Cellulose Acetate Butyrate and Cellulose Propionate—Molded, Extruded

Type ⇒		Cellulose Acetate Butyrate			Cellulose Propionate[b]
		Type I[a] (Medium)	Type II[a] (Hard)	Type III[a] (Soft)	
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.16-1.24	1.19-1.25	1.15-1.22	1.18-1.24
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.10–0.19	0.10–0.19	0.10–0.19	0.10–0.19
Coef of Ther Exp (max), per °F	D696	6-9 x 10^{-5}	6-9 x 10^{-5}	6-9 x 10^{-5}	7-9 x 10^{-5}
Refractive Index	D542	1.46-1.49	1.46-1.49	1.46-1.49	1.46-1.48
Spec Ht, Btu/lb/°F		0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4
Transmittance (luminous), %	D791	80-90	75-90	85-95	80-90
Haze, %	D672	3-10	5-15	3-8	5-10
Water Absorption (24 hr), %	D570	1.3-2.1	1.5-2.2	1.1-2.1	1.2-2.0
Flammability, ipm[c]	D635	0.5-1.5	0.5-1.5	0.5-1.5	1.0-1.5
MECHANICAL PROPERTIES					
Ten Str, 1000 psi	D638	2.9-5.7	5.0-6.8	1.9-3.8	1.5-7.5
Elong, %		47-66	38-54	60-74	50-60
Hardness (Rockwell)		R79-112	R108-114	R59-95	R20-120
Impact Str (Izod notched), ft-lb/in.	D256	1.0-4.3	0.6-2.4	2.5-5.4	0.8-11.0
Mod of Elast in Flex, psi		0.93–1.7 x 10^5	1.5–2.0 x 10^5	0.74–1.3 x 10^5	1.6–3.3 x 10^5
Flex Str, 1000 psi		No break	No break	No break	No break
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{10}-10^{12}	10^{10}-10^{12}	10^{10}-10^{12}	10^{12}-10^{15}
Dielec Str (short time), v/mil	D149	250-400	250-400	250-400	300-450
Dielec Const					
60 Cycles	D150	3.5-6.4	3.5-6.4	3.5-6.4	—
10^6 Cycles	D150	3.2-6.2	3.2-6.2	3.2-6.2	3.4-3.6
Dissip Factor					
60 Cycles	D150	0.01-0.04	0.01-0.04	0.01-0.04	—
10^6 Cycles	D150	0.01-0.04	0.01-0.04	0.01-0.04	0.02-0.03
FABRICATING PROPERTIES					
Bulk Factor		2.0-2.4	2.0-2.4	2.0-2.4	1.6-2.0
Compression Molding					
Pressure, 1000 psi		0.5-5	0.5-5	0.5-5	—
Temperature, F		285-340	320-390	265-305	—
Injection Molding					
Pressure, 1000 psi		8-32	8-32	8-32	8-32
Temperature, F		355-440	390-480	335-395	310-480
Mold Shrinkage, in./in.		0.001-0.008	0.001-0.009	0.001-0.006	0.002-0.006
HEAT RESISTANCE					
Heat Dist Temp, F					
66 Psi	D648	156-197	188-233	139-164	130-200
264 Psi	D648	130-172	158-210	121-137	—
CHEMICAL RESISTANCE		Unaffected by 30% sulfuric, 5% acetic, 10% hydrochloric and oleic acids; discolored by 10% nitric acid. Unaffected by 1% sodium hydroxide and 2% sodium carbonate; slightly softened by 10% sodium hydroxide and discolored by 10% ammonium hydroxide. Unaffected by white gasoline, but swollen or dissolved by ethyl alcohol, acetone, ethyl acetate, ethylene dichloride, carbon tetrachloride and toluene. Unaffected by water, salt water and 3% hydrogen peroxide			
USES		Telephone handsets, steering wheels, automobile white-wall disks, film spools, irrigation tubing, radio housings. Electrical items such as fluorescent light supports, coil spools and contact bases.			Pen and pencil parts. Other uses similar to those of butyrate

[a] ASTM D707-55T.

[b] Values given are for compounds having different plasticizer contents.

[c] Self-extinguishing cellulose acetate butyrate compounds are available.

Cellulose Nitrate and Ethyl Cellulose—Molded, Extruded

Type ➡		Cellulose Nitrate Sheet	Ethyl Cellulose Moldings		
			General Purpose	High Impact	
				A	B
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.35-1.40	1.10-1.16	1.10-1.16	1.10-1.16
Ther Cond, Btu/hr/sq ft/°F/ft	Cenco-Fitch	0.133	0.092-0.167	0.092-0.167	0.092-0.167
Coef of Ther Exp, 10^{-5} per °F	D696	4.4–6.6	5.5–11	5.5–11	5.5–11
Refractive Index	D542	1.49-1.51	1.47	1.47	1.47
Transmittance (luminous), %	D791	89-92[a]	—	—	—
Haze, %	D672	2.0-4.0[a]	—	—	—
Water Absorption (24 hr), %	D570	1.0-2.0	1.2-2.0	0.8-2.0	1.0-2.0
Flammability (>0.050 in.), ipm	D635	[b]	0.5-1.5	0.5-1.5	0.5-1.5
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	1.9-2.2	0.5-3.5	1.0-3.0	1.0-3.0
Ten Str, 1000 psi	D638	7-8	3-7	4-6.5	3-5
Strain at Fracture, %	D638	40-50	—	—	—
Hardness (Rockwell)	D785	R95-115	R80-120	R80-90	R70-80
Impact Str (Izod notched), ft-lb/in.	D758	5-7	1.7-6.0	3.5-6.0	4.0-7.0
Mod of Elast in Flex, 10^5 psi	D790	2.3-2.5	—	—	—
Flex Str, 1000 psi	D790	9-11[c]	4-10	6	4
Compr Str, 1000 psi	D695	22-35	—	—	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10-15 x 10^{10}	10^{12}-10^{14}	10^{12}-10^{14}	10^{12}-10^{14}
Dielec Str (short time), v/mil	D149	300-600	350-500	350-500	350-500
Dielec Const					
60 Cycles	D150	7.0-7.5	—	—	—
10^6 Cycles	D150	6.4	2.8-3.5	2.8-3.3	3.0-3.6
Dissip Factor					
60 Cycles	D150	0.09-0.12	—	—	—
10^6 Cycles	D150	0.06-0.09	0.010-0.060	0.010-0.030	0.018-0.035
FABRICATING PROPERTIES					
Bulk Factor		—	1.8-2.4	1.8-2.4	1.8-2.4
Compression Molding					
Pressure, 1000 psi		—	0.5-5	0.5-5	0.5-5
Temperature, F		—	250-390	250-390	250-390
Injection Molding					
Pressure, 1000 psi		—	6-32	8-32	8-32
Temperature, F		—	350-500	350-500	350-500
Hot Forming Temperature, F		135-250	—	—	—
Extruding Temperature, F		180-200	300-450	350-450	350-450
HEAT RESISTANCE					
Max Rec Svc Temp, F		120-140	—	—	—
Heat Dist Temp, F					
66 Psi		200-220	—	—	—
264 Psi		140-160	120-160	130-145	125-140
CHEMICAL RESISTANCE		Resistant to 30% sulfuric acid, carbon tetrachloride, 10% sodium chloride, 10% nitric acid, 10% hydrochloric acid, 5% acetic acid, 2% sodium tetrachloride, distilled water, aliphatic and aromatic hydrocarbons, and < 1% sodium hydroxide. Soluble in ketones, esters, lower alcohols and glycol ethers. Attacked by concentrated sodium hydroxide, ethylene dichloride and 50% ethanol	Unaffected by 3 sulfuric, 5 acetic and 10% hydrochloric acids; 10% sodium hydroxide, 2% sodium carbonate and water. Slightly affected by 30 sulfuric and 10% nitric acids; and 10% ammonium hydroxide. Attacked by 95% ethyl alcohol, acetone, toluene and gasoline		
USES		Fountain pens, spectacle frames, drawing instruments, ping-pong and billiard balls	Radio housings, toothbrushes, pen and pencil barrels, tool handles		

[a] $\frac{1}{8}$-in. sheet containing no color.

[b] Cellulose nitrate under 0.050 in. thick burns very rapidly (D568).

[c] No break; specimen failed by slipping through supports.

Diallyl Phthalate—Molded

Type ➡		Orlon-Filled	Dacron-Filled	Asbestos-Filled	Glass Fiber-Filled
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.31–1.34	1.40	1.65–1.70	1.55–1.59
Coef of Ther Exp, per °F	D696	1.5×10^{-5}	2.0×10^{-5}	3.5×10^{-5}	$2.2\text{–}2.6 \times 10^{-5}$
Water Abs (122 F, 48 hr), %		0.2–0.5	0.2	0.4–0.5	0.12–0.2
Flammability (ignition time), sec		68	84–90	70	400–450
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi[a]	D638	6×10^5	—	17×10^5	—
Ten Str, psi	D638	4500–6000	4600	4000–5500	5500–7000
Hardness (Rockwell)	D785	M108	—	M107	M100
Impact Str (Izod notched), ft-lb/in	D256	0.5–1.2	1.7–4.5	0.30–0.45	0.5–6.0
Flex Str, 1000 psi	D790	10–10.5	9–11.5	8–10	10–12
Compr Str, 1000 psi	D695	20–30	30	18–25	25
ELECTRICAL PROPERTIES					
Dielec Str, v/mil					
Short Time (dry)	D149	366	376–390	378	382–430
Short Time (wet[b])	D149	375	360–391	330	345–420
Step by Step (dry)	D149	364	350–374	320–350	335–420
Step by Step (wet[b])	D149	333	350–361	225–250	295–420
Dielec Breakdown, kv					
Short Time (dry)		55–81.7	70–80	55–80	63–70
Short Time (wet[b])		60–65	66–70	55	45–65
Step by Step (dry)		55–60.5	60–65	38–70	60–65
Step by Step (wet[b])		46–60	60	39–60	49.5–65
Dissip Factor[c]					
Dry	D150	0.023, 0.015	0.006, 0.012	0.039, 0.040	0.004, 0.010
Wet[d]	D150	0.026, 0.020	0.009, 0.017	0.042, 0.154	0.008, 0.015
Dielec Const[c]					
Dry	D150	3.9, 3.3	3.8, 3.4	5.2, 4.5	4.5, 4.2
Wet[d]	D150	4.1, 3.3	3.8, 3.6	4.8, 4.7	4.6, 4.4
Vol Res, megohm-cm[d]	D257	60,000	100–25,000	6000	1000
Surface Res, megohms[d]	D257	25,000	500–10,000	6000	500
Arc Resistance, sec	D495	85–115	105–125	125–140	125
FABRICATING PROPERTIES					
Bulk Factor	D392	3.5–5.2	5.2	1.9–2.4	1.9–4.0
Compression Molding					
Pressure, psi		500–2000	500–2000	500–2000	500–2000
Temperature, F		270–320	270–320	270–320	270–320
Transfer Molding					
Pressure, psi		1000–5000	1000–5000	1000–5000	1000–5000
Temperature, F		270–310	270–310	270–310	270–310
Mold Shrinkage, in./in.		0.009	0.010	0.004–0.007	0.004
Post-Mold Shrinkage (480 hr, 257 F), in./in.		0.001	0.0006	0.0005	0.0005–0.0007
HEAT RESISTANCE					
Max Rec Svc Temp, F		300	300–370	350–450	400–450
Heat Dist Temp, F	D648	240–266	270–290	300–350	300–350
CHEMICAL RESISTANCE		Unaffected by weak acids and alkalis and organic solvents. Slightly affected by strong acids and alkalis			

[a] Conditioned 48 hr at 122 F.
[b] Tested after 48-hr immersion in water at 122 F.
[c] Values given for frequencies of 1 kc and 1 mc, in that order.
[d] Conditioned 30 days at 100% RH and 158 F.

Epoxies—Cast, Molded

Type ➡		Cast			Molded[b]
		General Purpose	Resilient	Heat Resistant	
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.12–2.4	1.0–1.25	1.15–3.2	1.8–1.85
Ther Cond, Btu/hr/sq ft/°F/ft	D325	0.1–0.8	0.1	0.1–0.8	—
Coef of Ther Exp, per °F	D696	1.7–5.0 x 10^{-5}	2.8–4.4 x 10^{-5}	2.8–3.3 x 10^{-5}	1.4 x 10^{-5}[c]
Water Absorption (24 hr), %	D570	0.1–0.5	0.4	0.01–0.2	0.06
Linear Mold Shrinkage, in./in.		0.001–0.01	—	0.01	0.004–0.006
Flammability, ipm	D635	0.3 to self-exting	—	0.3 to self-exting	Self-exting
MECHANICAL PROPERTIES					
Ten Str, 1000 psi	D651	2–12	0.1–4.0	5–14	8–10
Elongation, %	D651	2–6	150–10	2–5	—
Hardness (Rockwell)	D785	M75–110	[a]	M90–110	M110
Impact Str (Izod), ft lb/in. notch	D256	0.2–0.7	0.5–7.0	0.2–1.5	0.3–0.8
Mod of Elast in Flex, 10^6 psi	D790	0.4–1.5	Up to 0.2	0.4–1.5	1.3–2.2
Flex Str, 1000 psi	D790	8–20	Up to 15	8–20	11–15.7[d]
Compr Str, 1000 psi	D695	20–40	3–20	25–40	25–26
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{12}–10^{14}	10^{11}–10^{12}	10^{13}–10^{14}	0.1–9 x 10^{15}
Dielec Str (1/8 in.), v/mil					
Short Time	D149	350–550	350–550	350–550	372–468
Step-by-Step	D149	350–550	350–550	350–550	334–450
Surface Res, ohms	D257	10^{12}–10^{14}	10^{12}–10^{13}	10^{12}–10^{14}	64 x 10^{13}
Dielectric Constant					
60 Cycles	D150	3.5–5.0	3.5–4.5	4.0–4.5	4.4–5.4
1000 Cycles	D150	3.5–5.0	3.3	3.8–4.1	—
10^6 Cycles	D150	3.4–4.4	2.6–2.8	3.5–4.0	4.1–4.6
Dissipation Factor					
60 Cycles	D150	0.001–0.015	0.05	0.005–0.013	—
1000 Cycles	D150	0.002–0.017	0.04	0.012–0.015	—
10^6 Cycles	D150	0.015–0.035	0.04	0.012–0.032	—
Loss Factor					
60 Cycles	D150	0.02–0.07	—	0.022	0.119–0.207
1000 Cycles	D150	0.02–0.09	—	0.053	—
10^6 Cycles	D150	0.09–0.13	—	0.12	0.111
Arc Resistance, sec	D495	65–100	—	65–120	148–180
HEAT RESISTANCE					
Max Rec Svc Temp, F		175	122	400	—
Heat Dist Temp (264 psi), F	D648	Up to 250	—	Up to 500	210–320
USES		Potting and encapsulation of electrical and electronic components, precision castings, tools and dies, patching compounds			New materials; primary uses probably electrical moldings of all types, such as condensers, switch plates, connector plugs, resistor bobbins and wirewound resistors, molded coils, relay assemblies

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[a] Shore A up to 100.

[b] Values cover range obtainable with mineral filler or mineral and glass fiber filler. Compounds designed for compression or transfer molding without release agents. Data, in some cases are preliminary.

[c] 77–140 F.

[d] After post-cure.

Fluorocarbons—Molded, Extruded

Type ➜		Polytrifluorochloro-ethylene	Polytetrafluoro-ethylene
PHYSICAL PROPERTIES	ASTM		
Specific Gravity	D792	2.10–2.15	2.1–2.3
Ther Cond, Btu/hr/sq ft/°F/ft	[a]	0.035–0.036	0.034
Coef of Ther Exp, per °F	D696	3.88×10^{-5}	5.5×10^{-5}
Refractive Index	D542	1.43	1.35
Specific Heat, Btu/lb/°F		0.22	0.25
Transmittance (luminous), %	D791	80–92	—
Water Absorption (24 hr), %	D570	0.00	0.00
Flammability		Nonflammable	Nonflammable
MECHANICAL PROPERTIES			
Mod of Elast in Compression, psi	D638	1.8×10^5	$0.70–0.90 \times 10^5$
Mod of Elast in Tension, psi	D638	$1.9–3.0 \times 10^5$	$0.38–0.65 \times 10^5$
Tensile Strength, 1000 psi	D638	4.6–5.7	1.5–3.0
Elongation (in 2 in.), %	D638	28–87	120–350
Hardness (Rockwell)	D785	R110–115	J75–95
Abrasion Resistance, gm/cycle	[b]	0.0080	—
Impact Strength (Izod notched), ft-lb/in.	D256	3.50–3.62	2.5–4.0
Mod of Elast in Flexure, psi	D747	$2.0–2.5 \times 10^5$	0.6×10^5
Flexural Strength (0.1% offset), 1000 psi	D790	—	1.6
Compressive Strength (0.1% offset), 1000 psi	D695	2.0	0.7–1.8
ELECTRICAL PROPERTIES			
Volume Resistivity, ohm-cm	D257	10^{18}	10^{19}
Dielectric Strength (short time), v/mil	D149	530–600	400–500
Dielectric Constant			
60 Cycles	D150	2.6–2.7	2.0
10^6 Cycles	D150	2.30–2.37	2.0
Dissipation Factor			
60 Cycles	D150	0.02	0.0002
10^6 Cycles	D150	0.007–0.010	0.0002
Arc Resistance, sec		>360	>200
FABRICATING PROPERTIES			
Injection Molding			
Pressure, 1000 psi		5–30	—
Temperature, F		420–620	—
Compression Molding			
Pressure, 1000 psi		0.1–15	—
Temperature, F		445–525	—
Bulk Factor		2.5	—
Mold Shrinkage, in./in.		0.005–0.010	—
HEAT RESISTANCE			
Max Rec Svc Temp, F		380	500
Heat Dist Temp, F			
66 Psi	D648	196–291	—
264 Psi	D648	151–178	—
CHEMICAL RESISTANCE		Impervious to corrosive chemicals; highly resistant to most organic solvents. Swelling may occur with some highly halogenated and aromatic compounds	Inert to most chemicals and solvents with the exception of alkali metals. Halogenated solvents at high temperatures and pressure have some effect
USES		Chemical pipes, gaskets, pump parts, electrical cables, tank linings, connectors, coil forms, connector inserts, valve diaphragms, electrical insulation	Chemical pipes, valves and valve liners, gaskets and packings, pump bearings and impellers, electrical and electronic equipment, anti-adhesive coatings

[a] Cenco-Fitch.
[b] Federal Spec L-P-406A #1092.1.

Melamines—Molded

Filler and Type →		Alpha Cellulose—General Purpose	Mineral—Electrical	Fabric—Low to Intermediate Shock Resistant	Fabric—Intermediate Resistance
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.47–1.52	1.7–2.0	1.5	1.5
Ther Cond, Btu/hr/sq ft/°F/ft		0.17–0.24	0.32–0.41	0.257	0.25–0.26
Coef of Ther Exp per °F	D696	1.11–3.17 x 10^{-5}	1.06–2.50 x 10^{-5}	1.55 x 10^{-5}	1.55 x 10^{-5}
Transmittance (luminous), %	D570	14.5	Opaque	Low	—
Water Absorption (24 hr), %	D570	0.1–0.6	0.08–0.14	0.3–0.6	0.2–1.3
Flammability		Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	D638	13–16 x 10^5	16–19.5 x 10^5	16 x 10^5	16 x 10^5
Ten Str, 1000 psi	D638	7–10	5.5–7.0	8–9.5	5.7–9
Elong (in 2 in.), %	D638	—	0.30–0.45	0.6–0.8	0.6
Hardness (Rockwell)	D785	M118–124, E110	M110	M120	M115
Impact Str (Izod notched), ft-lb/in.	D256	0.24–0.35	0.28–0.40	0.5–0.9	1.0–1.5
Mod of Elast in Flex, psi	D790	15 x 10^5	16 x 10^5	18.5 x 10^5	19 x 10^5
Compr Str, 1000 psi	D695	40–45	25–30	30–35	25–32
Flex Str, 1000 psi	D790	10–16	8.7–11	12–15	13–17
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{12}–10^{14}	10^{11}–10^{13}	10^{9}–10^{12}	—
Dielec Str (short time), v/mil	D149	310–330	350–430	250–350	130–370
Dielec Const					
60 Cycles	D150	8.4–9.4	6.4–10.2	7.6–8.6	10.5–15.5
10^6 Cycles	D150	5.6–5.8	6.1–6.7	6.5–6.9	6.1–6.7
Dissip Factor					
60 Cycles		0.05–0.08	0.07–0.17	0.07–0.11	0.10–0.32
10^6 Cycles		0.03–0.04	0.04–0.05	0.036	0.050–0.065
Arc Resistance, sec	D495	122–128	120–170	115–128	5–8
FABRICATING PROPERTIES					
Bulk Factor	D392	2.1–3.1	2.1–2.5	5–10	5–10
Compression Molding					
Pressure, 1000 psi		1.5–8	1–7	4–8	4–8
Temperature, F		280–370	275–340	275–330	300–380
Transfer Molding					
Pressure, 1000 psi		4–12	4–20	—	—
Temperature, F		300–320	270–340	—	—
Mold Shrinkage, in./in.		0.006–0.015	0.003–0.007	0.003–0.004	0.004–0.005
HEAT RESISTANCE					
Max Rec Svc Temp, F		210	250–400	250	250
Heat Dist Temp (264 psi), F	D648	350–410	265	310	375
CHEMICAL RESISTANCE		Resistant to weak acids, weak alkalis, organic solvents, greases and oils. Attacked by strong acids and strong alkalis			
USES		General purpose electrical and mechanical applications such as kitchenware, tableware, lighting fixtures, reflectors	Elevated temperature and electrical applications such as ignition parts, circuit breakers, terminal blocks, electronic parts	Applications requiring improved impact strength, such as insulation, circuit breakers, food trays, medical equipment	Applications requiring medium impact strength, such as nozzles, insulation

Melamines—Molded

Filler and Type ➜		Unfilled	Cellulose Electrical	Glass Fiber	Alpha Cellulose and Mineral
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.48	1.43–1.50	1.9–2.0	1.49
Ther Cond, Btu/hr/sq ft/°F/ft		—	0.17–0.20	0.28	—
Coef of Ther Exp, per °F	D696	—	1.11–2.78 x 10^{-5}	0.82 x 10^{-5}	—
Transmittance (luminous), %		Good	Opaque	—	—
Water Absorption (24 hr), %	D570	0.3–0.5	0.27–0.80	0.10–0.60	0.5
Flammability	D570	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	D638	—	10–11 x 10^5	—	—
Ten Str, 1000 psi	D638	—	5–9	6–10	5
Elong (in 2 in.), %	D638	—	0.6	—	—
Hardness (Rockwell)	D785	—	M115–125	—	—
Impact Str (Izod notched), ft-lb/in.	D256	—	0.27–0.36	4.0–12.0	0.30
Mod of Elast in Flex, psi	D790	13 x 10^5	1.0–1.3 x 10^5	—	—
Comp Str, 1000 psi	D695	40–45	25–33.6	26–32	—
Flex Str, 1000 psi	D790	11–14	9–10	10–23	8
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	—	10^{12}–10^{13}	1–7 x 10^{11}	10^{12}
Dielec Str (short time), v/mil	D149	—	350–400	250–300	375
Dielec Const					
60 Cycles	D150	—	6.2–7.6	9.7–11.1	—
10^6 Cycles	D150	—	4.7–7.0	6.9–7.2	6.4
Dissip Factor					
60 Cycles		—	0.019–0.033	0.14–0.23	—
10^6 Cycles		—	0.032–0.06	0.02–0.03	0.031
Arc Resistance, sec	D495	100–145	95–135	180–186	125
FABRICATING PROPERTIES					
Bulk Factor	D392	2.0	2.2–2.6	5–7	2.4
Compression Molding					
Pressure, 1000 psi		2–5	1.5–3	2–8	2–5
Temperature, F		300–340	290–360	280–340	280–350
Transfer Molding					
Pressure, 1000 psi		—	6–20	8–20	2–10
Temperature, F		—	300–330	290–310	285–350
Mold Shrinkage, in./in.		0.011–0.012	0.006–0.008	0.001–0.004	0.006–0.007
HEAT RESISTANCE					
Max Rec Svc Temp, F		210	250–280	300–400	275–325
Heat Dist Temp (264 psi), F	D648	293–298	265	400	300
CHEMICAL RESISTANCE		Resistant to weak acids, weak alkalis, organic solvents, greases and oils. Attacked by strong acids and strong alkalis			
USES		Pearlescent buttons, moldings ornamental applications	General mechanical and electrical applications, particularly at elevated temperatures. Applications requiring improved holding power for metallic inserts such as electrical and electronic parts	Applications requiring high shock resistance, good electrical properties, and high resistance to burning. Switchgear, terminal strips, standoff insulators, coil forms	Primarily electrical applications requiring low after-shrinkage, good dimensional stability and excellent molding characteristics

Polyamides (Nylons)—Molded, Extruded

Type ➡		66 Nylon			610 Nylon	
		General Purpose Injection Molding		Extrusion and Injection Molding	Extrusion and Injection Molding	
		0.2% Water	2.5% Water		0.2% Water	1.5% Water
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	1.14	—	1.14	1.09	—
Ther Cond, Btu/hr/sq ft/°F/ft	[a]	0.14	—	0.142	0.12	—
Coef of Ther Exp, 10^{-5} per °F	D696	5.5	—	5.5	5.5	—
Spec Ht, Btu/lb/°F		0.3–0.5	—	0.4	0.3–0.5	—
Refractive Index	D542	1.53	—	—	1.53	—
Water Absorption (24 hr), %	D570	1.5	—	1.5	0.4	—
Flammability	D757	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	4.1	2.1	4.0	2.8	1.6
Ten Str, 1000 psi	D638	11.8	11.2	11.2–12.6	8.5	7.1
Elong (in 2 in.), %	D638	60	300	100–200	85	320
Hardness (Rockwell)	D785	M79, R118	M59, R108	R118	R111	—
Impact Str (Izod notched), ft-lb/in.	D256	0.9	2.0	1.1–1.5	0.6	1.6
Mod of Elast in Flex, 10^5 psi	D790	4.1	2.1	—	2.8	1.6
Flex Yld Str, 1000 psi	D790	13.8	—	13.8	8	—
Compr Yld Str, 1000 psi	D695	13	—	—	7.2	—
Compr Yld Str (1% def), 1000 psi	D695	—	—	4.9	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	—	—	4.5 x 10^{13}	—	—
Dielec Str (short time), v/mil	D149	385	—	385	470	—
Dielec Const						
60 Cycles	D150	4.0	7.6	4.1	3.9	—
10^6 Cycles	D150	3.6	3.6	3.4	—	—
Dissip Factor						
60 Cycles	D150	0.01	0.09	0.014	—	—
10^6 Cycles	D150	0.02	0.08	0.04	0.02	—
Arc Resistance, sec	D495	—	—	—	—	—
FABRICATING PROPERTIES						
Bulk Factor	D392	2.1	—	2.14	2.2	—
Injection Molding						
Pressure, 1000 psi		10–20	—	—	10–20	—
Temperature, F		520–650	—	—	450–600	—
Joining		Can be cemented with aqueous phenol or various proprietary adhesives. Spin welding, extrusion lamination and other techniques can be used in special cases				
HEAT RESISTANCE						
Max Rec Svc Temp, F		275–300	—	—	225	—
Heat Dist Temp, F						
66 Psi	D648	—	—	360	—	—
264 Psi	D648	—	—	150	—	—
CHEMICAL RESISTANCE		Inert to most organic chemicals such as esters, ketones, alcohols and hydrocarbons. Resist alkalis and salt solutions, but attacked by phenols, formic acid, mineral acid and strong oxidizing agents				
USES		Gears, bearings, automatic washing machine valves, rollers and slides, combs and brush backs, aerosol bottles, coil forms, and mechanical parts where lubrication is undesirable or difficult		Tubing, rods, pipe, sheeting, laminations	Jacketing for wire and cable; special molded parts	

[a] Cenco-Fitch.

Polyamides (Nylons)—Molded, Extruded

Type →		6 Nylon		11 Nylon	Soluble Resin (solution, injection, extrusion)	Glass Fiber-Filled[d]
		General Purpose Injection Molding	Extrusion and Injection Molding			
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	1.13-1.14	1.14	1.1	1.12-1.13	1.30-1.36
Ther Cond, Btu/hr/sq ft/°F/ft	[a]	0.10-0.14	0.11-0.12	—	0.16	—
Coef of Ther Exp, 10^{-5} per °F	D696	4.6-5.4	4.6-7.1	5.5	8.2	1.6-2.1
Spec Ht, Btu/lb/°F		0.4	—	0.58	0.4	0.31
Water Absorption (24 hr), %	D570	1.6-2.0	2.1-3.3	0.4	2.0-5.5	0.2-1.4
Flammability	D757	Self-exting	Self-exting	Self-exting	Self-exting	Self-exting
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	2.5-3.4	1.5-3.6	1.8-1.9	0.38	—
Ten Str, 1000 psi	D638	10.2-12	10.2-11.3	8.5	3.8-7.4	19-22
Elong (in 2 in.), %	D638	300	300	100-120	300-600	1.5-2.0
Hardness (Rockwell)	D785	R105-118	R103-111	A50-55	R45-83	M94-100
Impact Str (Izod notched), ft-lb/in.	D256	1.2-3.0	1.5-3.5	3.3-3.6	>16	2.5-3.5
Flex Yld Str, 1000 psi	D790	15.5	—	—	1-2	—
Compr Yld Str (1% def), 1000 psi	D695	7.1-9.7	6.7-8.8	—	0.8	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	10^{13}-10^{15}	10^{13}-10^{15}	2×10^{13}	5×10^{13}	1.5-5.5×10^{15}
Dielec Str (short time), v/mil	D149	420-485	440-500	425	420	408-503
Dielec Const						
60 Cycles	D150	4.5-11.5	5.1-14.0	3.3[c]	10.7	4.0-4.6
10^6 Cycles	D150	3.6-4.3	3.5-4.5	—	4.5	3.4-3.9
Dissip Factor						
60 Cycles	D150	0.03-0.07	0.06-0.10	0.03	0.19	0.018-0.022
10^6 Cycles	D150	0.03-0.13	0.03-0.11	0.02	0.14	0.017-0.019
Arc Resistance, sec	D495	—	—	—	—	92-148
FABRICATING PROPERTIES						
Bulk Factor	D392	1.60-1.68	1.72-1.82	2.2	2.5	2.0
Compression Molding						
Pressure, 1000 psi		—	—	—	1-2	—
Temperature, F		—	—	—	325-380	—
Injection Molding						
Pressure, 1000 psi		10-25	—	—	10-25	10-25
Temperature, F		440-550	—	—	300-500	500-650
Extruding Temp, F		450-550	430-550	—	500-550	—
Joining		Nylon adhesive or aqueous phenol		—	[b]	—
HEAT RESISTANCE						
Max Rec Svc Temp, F		225-250	200-250	212-250	140	300-350
Heat Dist Temp, F						
66 Psi	D648	340	—	—	100	—
264 Psi	D648	145	—	—	—	440-500
CHEMICAL RESISTANCE		Resists esters, ketones, alkalis, weak acids, alcohols and common solvents. Not resistant to conc mineral acids	Resists petroleum oils and greases, alkalis, esters, ketones, alcohols and common solvents. Not resistant to mineral acids	Similar to other nylons	Resists ketones, alkalis and esters. Not resistant to alcohols, phenols, formic acid, and mineral acids	Attacked by strong acids. Fairly resistant to strong alkalis. Resists common solvents
USES		Bearings, gears, bushings, coil forms, brush backs, rod, tubing, tape	Abrasion resistant shielding on insulated wire and mechanical cable. Pipe, tubing	Electrical insulation and other nylon uses where low moisture absorption is needed	Jacketing for wire and cable, seals, packings, sheeting, adhesives, abrasion-resistant finishes	Gears, business machine parts, appliance handles, terminal blocks, meter housings

[a] Cenco-Fitch.
[b] Can be bonded with 70-30 methanol-water as cement, or 10% solution of resin in methanol-water as solvent.
[c] At 1000 cps.
[d] Covers range obtainable in 3 grades.

Phenolics—Molded

Type and Filler ➡		General—Woodflour and Flock	Shock—Paper, Flock or Pulp	High Shock—Chopped Fabric or Cord	Very High Shock—Glass Fiber
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.32–1.55	1.34–1.46	1.36–1.43	1.75–1.90
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.097–0.170	0.1–0.16	0.097–0.170	—
Coef of Ther Exp, 10^{-5} per °F	D696	1.66–2.50	1.6–2.3	1.60–2.22	0.88
Spec Ht, Btu/lb/°F	D570	0.35–0.40	—	0.30–0.35	0.28–0.32
Water Absorption (24 hr), %	D635	0.3–0.8	0.4–1.5	0.4–1.75	0.1–1.0
Flammability		Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	8–13	8–12	9–14	30–33
Ten Str, 1000 psi	D638, D651	6.5–8.5	5.0–8.5	5–9	5–10
Elong (in 2 in.), %	D638	0.4–0.8	—	0.37–0.57	0.2
Hardness (Rockwell)	D785	M108–120	—	M93–120	M95–100
Impact Str (Izod notched), ft-lb/in.	D256	0.24–0.50	—	0.6–8.0	10–33
Mod of Elast in Flex, 10^5 psi		8–12	—	9–13	—
Flex Str, 1000 psi	D570	8.5–12	8.0–11.5	8–15	10–45
Compr Str, 1000 psi	D695	22–36	24–35	15–30	17–30
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^9–10^{13}	1–50 x 10^{11}	$>10^{10}$	7–10 x 10^{12}
Dielec Str (short time), v/mil	D149	200–425	250–350	200–350	200–370
Dielec Const					
60 Cycles	D150	5.0–9.0	5.6–11.0	6.5–15.0	7.1–7.2
10^6 Cycles	D150	4.0–7.0	4.5– 7.0	4.5– 7.0	4.6–6.6
Dissip Factor					
60 Cycles	D150	0.05–0.30	0.08–0.35	0.08–0.45	0.02–0.03
10^6 Cycles	D150	0.03–0.07	0.03–0.07	0.03–0.09	0.02
Arc Resistance, sec	D495	5	5	5	60
FABRICATING PROPERTIES					
Bulk Factor		2.1–4.4	2.3–5.7	3.0–18.0	6.1–6.3
Compression Molding					
Pressure, 1000 psi		1.5–5.0	2–5	2–6.5	1–5
Temperature, F		290–380	290–380	280–380	500–5000
Transfer Molding					
Pressure, 1000 psi		2–10	2–10	2–12	—
Temperature, F		275–340	275–340	275–340	—
Mold Shrinkage, in./in.		0.005–0.008	0.004–0.009	0.002–0.009	0.0
HEAT RESISTANCE					
Max Rec Svc Temp, F		300–350	300	250–275	350–450
Heat Dist Temp, F	D648	260–340	290–340	250–340	600
CHEMICAL RESISTANCE		Severely attacked by strong acids and strong alkalis. Effects of dilute acids, alkalis and organic solvents vary with the reagent. Chemical resistance varies with the particular formulation and not all materials of a type are equally resistant			
USES		Mechanical applications include pulleys, wheels, motor housings, handles. Electrical uses include coil forms, ignition parts, condenser housings, fuse blocks, instrument panels. Thermal applications include handles, appliance connector plugs. Chemical uses include photographic development tanks, rayon spinning buckets and parts, milking machine cups. Decorative uses include radio and television cabinets, handles, knobs, buttons			

Phenolics—Molded

Type and Filler ➔		High Frequency—Mineral	Shock & Heat—Mineral, Flour and Yarn	Heat—Mineral	Chemical (no filler)
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.75–1.92	1.68–2.00	1.54–1.75	1.24–1.90
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.24–0.34	0.19–0.39	0.19–0.39	—
Coef of Ther Exp, 10^{-5} per °F	D696	1.05–1.44	0.83–1.17	1.17	2.4
Spec Ht, Btu/lb/°F	D570	0.28–0.32	0.28–0.32	0.28–0.32	—
Water Absorption (24 hr), %	D635	0.01–0.07	0.1–0.5	0.2–0.5	0.15–0.60
Flammability		Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	30–50	15–25	10–20	7–15
Ten Str, 1000 psi	D638, D651	5–7	4–9	4–6.5	4.5–7.5
Elong (in 2 in.), %	D638	0.10–0.53	—	—	—
Hardness (Rockwell)	D785	M100–110	M100–110	M98–115	M105–120
Impact Str (Izod notched), ft-lb/in.	D256	0.30–0.38	0.27–3.50	0.24–0.40	0.2–0.6
Mod of Elast in Flex, 10^5 psi		30–40	10–25	10–20	7–15
Flex Str, 1000 psi	D570	8–12	7–15	3–10.5	7–12
Compr Str, 1000 psi	D695	15–25	15–25	15–35	18–32
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{13}	10^{10}–10^{12}	10^{11}–10^{12}	10^{1} –10^{12}
Dielec Str (short time), v/mil	D149	300–375	100–250	150–350	225–275
Dielec Const					
60 Cycles	D150	4.7–5.5	30–150	5.8–40.0	9–19
10^6 Cycles	D150	4.4–5.1	5–7	4.8– 8.0	5.5–7.0
Dissip Factor					
60 Cycles	D150	0.01–0.07	0.25–0.50	0.10–0.35	0.15–0.25
10^6 Cycles	D150	0.005–0.02	0.10–0.50	0.04–0.15	0.04–0.09
Arc Resistance, sec	D495	16	6	5–120	—
FABRICATING PROPERTIES					
Bulk Factor		2.1–2.7	3–14	2.0–2.8	1.9–3.0
Compression Molding					
Pressure, 1000 psi		2.0–5.5	2–6	2–6	2–6
Temperature, F		300–350	290–380	290–380	300–360
Transfer Molding					
Pressure, 1000 psi		2–10	2–12	2–9	2–10
Temperature, F		275–325	275–325	275–325	275–340
Mold Shrinkage, in./in.		0.003	0.0005–0.005	0.002–0.006	0.002–0.01
HEAT RESISTANCE					
Max Rec Svc Temp, F		250–300	350–400	375–425	300–425
Heat Dist Temp, F	D648	230–325	290–375	350–400	300–350
CHEMICAL RESISTANCE		Severely attacked by strong acids and strong alkalis. Effects of dilute acids, alkalis and organic solvents vary with the reagent. Chemical resistance varies with the particular formulation and not all materials of a type are equally resistant			
USES		Mechanical applications include pulleys, wheels, motor housings, handles. Electrical uses include coil forms, ignition parts, condenser housings, fuse blocks, instrument panels. Thermal applications include handles, appliance connector plugs. Chemical uses include photographic development tanks, rayon spinning buckets and parts, milking machine cups. Decorative uses include radio and television cabinets, handles, knobs, buttons			

continued on next page

Phenolics—Molded

Type and Filler ➜		Arc Resistant—Mineral	Rubber Phenolic—Woodflour or Flock	Rubber Phenolic—Chopped Fabric	Rubber Phenolic—Asbestos
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.8–3.0	1.24–1.35	1.30–1.35	1.60–1.65
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.24–0.34	0.12	0.05	0.04
Coef of Ther Exp, 10^{-5} per °F	D696	—	0.83–2.20	1.7	2.2
Spec Ht, Btu/lb/°F	D570	0.28–0.32	0.33	—	—
Water Absorption (24 hr), %	D635	0.2	0.5–2.0	0.5–2.0	0.10–0.50
Flammability		Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	—	4–6	3.5–6	5–9
Ten Str, 1000 psi	D638, D651	6	4.5–9	3.5	4
Elong (in 2 in.), %	D638	—	0.75–2.25	—	—
Hardness (Rockwell)	D785	—	M40–90	M57	M50
Impact Str (Izod notched), ft-lb/in.	D256	0.32	0.34–1.0	2.0–2.3	0.3–0.4
Mod of Elast in Flex, 10^5 psi		—	4–6	3.5	5.0
Flex Str, 1000 psi	D570	10	7–12	7	7
Compr Str, 1000 psi	D695	20	12–20	10–15	10–20
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	6×10^{12}	10^6–10^{11}	10^{11}	10^{11}
Dielec Str (short time), v/mil	D149	380	250–375	250	350
Dielec Const					
60 Cycles	D150	7.4	9–16	15	15
10^6 Cycles	D150	—	5	5	5
Dissip Factor					
60 Cycles	D150	—	0.15–0.60	0.5	0.15
10^6 Cycles	D150	0.10	0.1–0.2	0.09	0.13
Arc Resistance, sec	D495	180	7–20	10–20	5–20
FABRICATING PROPERTIES					
Bulk Factor		2.4	2.5–4.0	4.6–8.0	2.5
Compression Molding					
Pressure, 1000 psi		2–5	2–6	2–6	2–6
Temperature, F		285–350	300–360	300–350	300–350
Transfer Molding					
Pressure, 1000 psi		2–10	2–12	2–12	2–12
Temperature, F		285–350	300–350	300–350	300–350
Mold Shrinkage, in./in.		0.004	0.005–0.010	0.003–0.006	0.005–0.008
HEAT RESISTANCE					
Max Rec Svc Temp, F		400	212–300	212–225	225–260
Heat Dist Temp, F	D648	335	220–270	220–280	250–300
CHEMICAL RESISTANCE		Severely attacked by strong acids and strong alkalis. Effects of dilute acids, alkalis and organic solvents vary with the reagent. Chemical resistance varies with the particular formulation and not all materials of a type are equally resistant			
USES		Mechanical applications include pulleys, wheels, motor housings, handles. Electrical uses include coil forms, ignition parts, condenser housings, fuse blocks, instrument panels. Thermal applications include handles, appliance connector plugs. Chemical uses include photographic development tanks, rayon spinning buckets and parts, milking machine cups. Decorative uses include radio and television cabinets, handles, knobs, buttons			

Phenolics—Cast

Type ➜		Type I— Mechanical and Chemical	Type II— General Purpose Decorative	Type III— General Purpose Transparent
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792	1.31	1.32	1.33
Coef of Ther Exp, per °F	D696	$3.3\text{–}4.4 \times 10^{-5}$	$3.3\text{–}5.5 \times 10^{-5}$	$4.7\text{–}6.6 \times 10^{-5}$
Water Absorption (24 hr), %	D570	0.35–0.40	0.32–0.35	0.3–2.0
Flammability (>0.050 in.)	D635	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638	$4\text{–}5 \times 10^5$	$3\text{–}4.5 \times 10^5$	$1\text{–}3 \times 10^5$
Tensile Strength, 1000 psi	D638	6–9	5–7.2	2.5–4.5
Hardness (Rockwell)	D785	M93–120	M90–105	R98–120
Impact Strength (Izod notched), ft-lb/in	D256	0.25–0.40	0.30–0.45	0.23–0.35
Mod of Elast in Flexure, psi	D790	$3\text{–}5 \times 10^5$	$3\text{–}5 \times 10^5$	$1\text{–}3 \times 10^5$
Flexural Strength, 1000 psi	D790	11–17	10–15	4–7
Compressive Yield Strength (1% offset), 1000 psi	D695	14–18	12.8–15.8	4.5–6.5
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	$1\text{–}7 \times 10^{12}$	$1\text{–}3 \times 10^{12}$	3×10^{11}
Dielectric Strength (short time), v/mil	D149	350–400	300–450	75–250
Dielectric Constant				
60 Cycles	D150	6.5–7.5	15–20	20–30
10^6 Cycles	D150	4.0–5.5	5.0–11.0	7–8
Loss Factor				
60 Cycles	D150	0.05–0.9	0.4–4.0	5.0–17.0
10^6 Cycles	D150	0.15–0.35	0.05–1.10	0.6–0.8
FABRICATING PROPERTIES	—	Castings produced by pouring resins into molds (generally made of lead). Resins converted to solid by heating several days at atmospheric pressure and temperatures below 212 F. After oven baking, casting is removed from mold and is ready for machining and polishing		
HEAT RESISTANCE				
Heat Dist Temp, F				
66 Psi	D648	—	150–160	125–135
264 Psi	D648	165–175	130–140	100–125
CHEMICAL RESISTANCE		Unless specially formulated, do not resist strong alkalis or strong acids. Dilute alkalis: slight to marked attack depending on alkali. Dilute acids: no effect or slight decomposition depending on acid. Continuous immersion in acetone, Cellosolve, methyl alcohol or ethyl alcohol results in noticeable attack, depending on time, temperature and hardness of cast resin		
USES		Drill and saw jigs, stretch press molds and dies for fabricating aircraft parts, furniture hardware, instrument casings, sporting goods, costume and ornamental jewelry		

Polyesters—Cast

Type →		Allyl Type	Rigid Styrene Type	Nonrigid Styrene Type
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792	1.30–1.45	1.12–1.46	1.06–1.25
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.116–0.121	0.10–0.12	—
Coef of Ther Exp, per °F	D696	$2.8\text{–}5.6 \times 10^{-5}$	$3.9\text{–}5.6 \times 10^{-5}$	—
Refractive Index	D542	1.50–1.58	1.53–1.58	1.50–1.57
Specific Heat, Btu/lb/°F		0.26–0.55	0.30–0.55	—
Water Absorption (24 hr), %	D570	0.03–1.0	0.15–0.60	0.40–2.5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638	$2\text{–}3 \times 10^{5}$	$1.5\text{–}6.5 \times 10^{5}$	—
Tensile Strength, 1000 psi	D638	4.5–7	4–10	0.9–1.9
Elongation (in 2 in.), %	D638	—	<5	40–310
Hardness (Rockwell)	D785	M92–118	M65–115	—
Impact Strength (Izod notched), ft-lb/in.	D256	0.18–0.32	0.18–0.40	>7.0
Mod of Elast in Flexure, psi		$3\text{–}8 \times 10^{5}$	$3\text{–}9 \times 10^{5}$	$0.001\text{–}0.1 \times 10^{5}$
Flexural Strength, 1000 psi	D790	6–14	7–19	—
Compressive Strength, 1000 psi	D695	20–26	12–37	—
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	$>10^{13}$	$>10^{13}$	$>10^{12}$
Dielectric Strength (short time), v/mil	D149	330–500	340–570	220–400
Dielectric Constant				
60 Cycles	D150	3.2–5.2	2.8–4.4	4.2–7.0
10^6 Cycles	D150	3.3–4.8	2.8–4.0	3.7–6.1
Dissipation Factor				
60 Cycles	D150	0.006–0.02	0.003–0.04	0.02–0.18
10^6 Cycles	D150	0.024–0.045	0.006–0.04	0.02–0.06
Arc Resistance, sec	D495	120–150	115–135	125–145
HEAT RESISTANCE				
Max Rec Svc Temp, F	D648	300	250–300	200–250
Heat Dist Temp, F		120–320	120–420	250
CHEMICAL RESISTANCE		Attacked by oxidizing acids. Slightly attacked by strong alkalis. Resistant to organic solvents	Slightly to heavily attacked by strong acids. Attacked by strong alkalis, ketones and chlorinated solvents	
USES		Castings used for aircraft glazing, electrical components, decorative applications. Resins used for premix and prepreg molding materials, matched metal molding and hand lay-up molding		

Silicones—Molded

Type and Filler ➜	ASTM	General—Mineral	Improved Impact—Glass Fiber	High Impact—Glass Fiber
PHYSICAL PROPERTIES				
Specific Gravity	D792	1.8–2.0	1.8–2.0	1.65–2.00
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.089–0.097	0.089–0.097	0.089–0.097
Coef of Ther Exp, per °F	D696	$2.78\text{–}3.23 \times 10^{-5}$	$3.17\text{–}3.23 \times 10^{-5}$	0.45×10^{-5}
Water Absorption (24 hr), %	D570	0.2–0.4	0.4–0.5	0.1–0.5
Flammability, ipm	D635	0–78	0–60	25–100
MECHANICAL PROPERTIES				
Tensile Strength, 1000 psi	D651	4–4.3	4–4.3	4.4–5
Hardness (Rockwell)	D785	M89	M89	M45
Impact Strength (Izod notched), ft-lb/in.	D256	0.25–0.30	0.33–0.38	3.00–6.00
Mod of Elast in Flexure, psi	D790	$10\text{–}13 \times 10^{5}$	$9\text{–}11 \times 10^{5}$	$15\text{–}19 \times 10^{5}$
Flexural Strength, 1000 psi	D790	6.8–7.5	6.1–6.4	9–14
Compressive Strength, 1000 psi	D695	16–20	12–16	10–15
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	$>3.4 \times 10^{13}$	$>3.4 \times 10^{13}$	$>5 \times 10^{13}$
Dielectric Strength (short time), v/mil	D149	350–400	300–400	250–400
Dielectric Constant				
60 Cycles	D150	4.1–4.5	5.1–5.3	4.8–5.0
10^6 Cycles	D150	3.8–4.3	4.9–5.1	3.6–5.1
Dissipation Factor				
60 Cycles	D150	0.010–0.014	0.008–0.011	0.006–0.030
10^6 Cycles	D150	0.006–0.010	0.007–0.011	0.005–0.020
Arc Resistance, sec	D495	250–420	250–350	20–350
Loss Factor				
60 Cycles	D150	0.041–0.063	0.041–0.058	0.029–0.035
10^6 Cycles	D150	0.023–0.043	0.034–0.056	0.025–0.077
FABRICATING PROPERTIES				
Bulk Factor		2.1–2.6	2.3–2.8	6–9
Compression Molding				
Pressure, 1000 psi		2–4	2–4	1–5
Temperature, F		300–350	300–350	300–350
Transfer Molding				
Pressure, 1000 psi		3.5–15	3.5–15	4.5–15
Temperature, F		300–350	300–350	300–350
Mold Shrinkage, in./in.		0.006–0.010	0.005–0.008	0.003–0.005
HEAT RESISTANCE				
Max Res Svc Temp, F		>450	>450	>450
Heat Dist Temp, F	D648	>300	>300	>300
CHEMICAL RESISTANCE		Resistant to aviation gasoline, lubricating oil, and sulfuric and hydrochloric acids. Slightly softened and pitted by sodium hydroxide, except some of the mineral-filled materials. Should be tested if resistance to ketones, toluene, ethylenes, etc., is required		
USES		Motor slot wedges, terminal boards, connector plugs, switches and insulators, aircraft brake assemblies, jet engine parts, aircraft ignition systems, guided missile parts		

Polystyrenes and Modified Polystyrenes—Molded, Extruded

Type ➜		Polystyrene		Modified Polystyrene		
		General Purpose	Glass Fiber-Filled	Heat & Chemical Resistant	Medium-High Impact[c]	Extra High Impact
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	1.04–1.07	1.25–1.32	1.05–1.11	1.04–1.08	1.0–1.10
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.058–0.080	—	0.046–0.072	0.024–0.072	0.024–0.073
Coef of Ther Exp, 10^{-5} per °F	D696	3.3–4.4	1.8–1.9	3.8	3.3–4.7	2.2–5.6
Spec Ht, Btu/lb/°F		0.32–0.35	—	0.32–0.35	0.30–0.35	0.30–0.35
Refractive Index	D542	1.58–1.60	Low	1.58–1.60	—	—
Transmittance (luminous), %		0–93	—	—	—	—
Water Absorption (24 hr), %	D570	0.03–0.05	0.07	0.1–0.3	0.03–0.08	0.05–0.20
Flammability, ipm	D635	1.0–1.5	—	0.4–0.7	0.5–2.0	0.5–2.0
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	4–5	12	4–6	3.0–4.5	2.5–4.0
Ten Str, 1000 psi	D638	5–8	10–15	10–11	3.5–6.8	3.0–5.5
Elong (in 2 in.), %	D638	1.5–2.4	0.75–1.0	1–3	5–35	15–45
Hardness (Rockwell)	D785	M68–80	M91–95	M78–88	M15–80	M15–60
Impact Str (Izod), ft-lb/in. notch	D256	0.25–0.35	1.8–4.3	0.25–0.50	0.6–3.0	6–11
Mod of Elast in Flex, 10^5 psi		4–5	—	4–6	3–5	2.3–4.0
Flex Str, 1000 psi	D790	8–15	16	11–17	No failure	No failure
Compr Str, 1000 psi	D695	11.5–16	13–15	12–17	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	10^{18}–10^{19}	2.6 x 10^{14}	10^{13}–10^{17}	10^{14}–10^{16}	10^{12}–10^{17}
Dielec Str (short time), v/mil	D149	>500	440–500	400–600	>450	300–650
Dielec Const						
60 Cycles	D150	—	3.11–3.22	2.7–3.4	2.45–2.70[d]	2.5–4.0
10^6 Cycles	D150	2.45–2.65	2.94–2.98	2.7–3.1	—	2.5–4.0
Dissip Factor						
60 Cycles	D150	—	0.0364–0.0490	0.001–0.008	0.0004–0.01[d]	—
10^6 Cycles	D150	0.0001–0.0005	0.0019–0.0025	0.001–0.008	—	—
FABRICATING PROPERTIES						
Bulk Factor		1.6–2.3	—	1.6–2.3	1.6–2.3	1.6–2.3
Compression Molding						
Pressure, 1000 psi		1–7.5	2–5	1–5	1–8	1–8
Temperature, F		275–400	275–350	325–450	325–475	300–450
Injection Molding						
Pressure, 1000 psi		10–24	15–20	10–24	10–24	10–30
Temperature, F		325–650	275–550	400–700	300–600	375–550
Mold Shrinkage, in./in.		0.002–0.008	0.001–0.005	0.002–0.008	0.002–0.008	0.002–0.0
HEAT RESISTANCE						
Max Rec Svc Temp, F		140–160[a]	190–200	175–190	125–165	120–160
Heat Dist Temp (264 psi), F	D648	165–190[b]	215–220	200–220	155–180	185–190
CHEMICAL RESISTANCE		Good resistance to alkalis, salts, lower alcohols, glycols, water. Fair resistance to mineral and vegetable oils. Soluble in aromatic and chlorinated hydrocarbons. Softened or attacked by higher alcohols, gasoline, strong oxidizing acids, chlorine		More resistant to attack by solvents, oils and other organic liquids than other polystyrenes	Similar to general purpose polystyrene	
USES		Electrical parts, incl storage battery cases, insulators, coil forms. Fluorescent light fixtures, rigid containers, instrument panels, nameplates, refrigerator parts, housewares, toys	Household utility cases, cabinet doors, storage drawers, meter housings	Battery cases, coil forms, drafting instruments, sight glasses on pressure lubricating systems, thermostat housings	Coat hangers; toilet seats; refrigerator door panels, drawers and crispers; knobs; toys; vacuum formed sheet	Freezer lids, action toys, children's furniture

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[a] 160–180 F for heat resistant grades.
[b] 180–205 F for heat resistant grades.
[c] Covers values obtainable in both Medium and High Impact grades.
[d] Average for wide frequency range.

ABS Resins and Methylstyrenes—Molded, Extruded

		ABS Resins			Methylstyrene[b]	
Type ➡		Medium–High Impact[a]	Extra–High Impact	Low Temp Impact	Polymethylstyrene	Methylstyrene–Acrylonitrile
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	1.04–1.06	1.01–1.06	1.02	1.01–1.03	1.06
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.08–0.12	0.08–0.12	0.08–0.12	—	—
Coef of Ther Exp, 10^{-5} per °F	D696	4.7	4.7–5.6	4.7–5.6	—	—
Spec Ht, Btu/lb/°F		0.35–0.38	0.35–0.38	0.35–0.38	—	—
Refractive Index	D542	—	—	—	1.581	1.559
Transmittance (luminous), %		—	—	—	Transparent	Transparent
Water Absorption (24 hr), %	D570	0.2	0.3	0.2	0.05	0.31
Flammability, ipm	D635	1.3	1.3	1.3	Slow	Slow
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	2.6–2.9	2.1–2.6	1.0	—	—
Ten Str, 1000 psi	D638	4 5–8.5	5–8	3–4	6.6–8.9	9.3
Elong (in 2 in.), %	D638	5–100	20–50	30–200	2.2–5.0	2.5
Hardness (Rockwell)	D785	R85–118	R85–100	R30–65	M76–83	M83
Impact Str (Izod), ft-lb/in. notch	D256	0.5–6.0	5–9	6–10	0.33	0.40
Mod of Elast in Flex, 10^5 psi		37–45	—	—	4.0	4.6
Flex Str, 1000 psi	D790	7.5–11.0	6.8–8.0	3–4	10–13	16
Compr Str, 1000 psi	D695	—	—	—	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	$>8 \times 10^{13}$	$1\ 8 \times 10^{13}$	$8.2–0.5 \times 10^{13}$	$2.6–5000 \times 10^{14}$	2.65×10^{11}
Dielec Str (short time), v/mil	D149	350–416	312	340–416	890–1950	610
Dielec Const						
60 Cycles	D150	2.7–4.2	2.7–4.76	2.7–4.0	—	—
10^6 Cycles	D150	2.8–3.6	3.78	2.8–4.1	2.48	2.81
Dissip Factor						
60 Cycles	D150	0.009–0.015	0.021	0.01	—	—
10^6 Cycles	D150	0.017–0.026	0.026	0.02	0.0006	0.0078
FABRICATING PROPERTIES						
Bulk Factor		2.25–2.27	2.29	2.27	—	—
Compression Molding						
Pressure, 1000 psi		>1	>1	>1	1–8	1–8
Temperature, F		325–375	325–375	325–375	300–375	300–375
Injection Molding						
Pressure, 1000 psi		6–30	6–30	6–30	10–30	10–30
Temperature, F		350–600	375–600	350–600	400–550	400–550
Mold Shrinkage, in./in.		0.001–0.010	0.001–0.010	0.001–0.010	0.0046	0.0035
HEAT RESISTANCE						
Max Rec Svc Temp, F		—	—	—	210	212
Heat Dist Temp (264 psi), F	D648	185–215	185	175–185	213–216	215
CHEMICAL RESISTANCE		Highly resistant to aqueous acids, alkalis, salts. Resistant to concentrated phosphoric and hydrochloric acids, alcohols, and animal, vegetable and mineral oils. Disintegrated by concentrated sulfuric and nitric acids. Soluble in esters, ketones, ethylene dichloride			Same as polystyrenes	Resists aliphatic hydrocarbons, gasoline, essential oils, vegetable and mineral oils
USES		Pipe, appliance housings and wheels, protective sportswear, housewares, howitzer cartridges			Radio cabinets, housewares and household utility parts, refrigerator parts, decorative lighting, packaging, electronic components	Same as polymethylstyrene. Also metering sight glasses, fan blades, combs, automotive interior parts, machine housings

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[a] Range covers values obtainable in both Medium and High Impact grades.
[b] Recently withdrawn from commercial production.

Polyethylenes—Molded, Extruded

Type →		**Type I—Lower Density** (0.910–0.925)			**Type II—Medium Density** (0.926–0.940)	
		Melt Index 0.3-3.6	**Melt Index 6-26**	**Melt Index 200**	**Melt Index 12.0**	**Melt Index 1.0-1.9**
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	0.910–0.925	0.918–0.925	0.910	0.930	0.930–0.940
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.19	0.19	0.19	0.19	0.19
Coef of Ther Exp, 10^{-5} per °F	D696	8.9–11.0	8.9–11.0	11.0	8.3–16.7	8.3–16.7
Refractive Index	D542	1.51	1.51	1.51	1.51	1.51
Spec Ht, Btu/lb/°F		0.53–0.55	0.53–0.55	0.53–0.55	0.53–0.55	0.53–0.55
Water Absorption (24 hr), %	D570	<0.01	<0.01	<0.01	<0.01	<0.01
Flammability, ipm	D635	1.0	1.0	1.0	1.0	1.0
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	0.21–0.27	0.20–0.24	—	—	—
Ten Str, 1000 psi	D412	1.4–2.5	1.4–2.0	0.9–1.1	2.0	2.3–2.4
Elong (in 2 in.), %	D412	500–725	125–675	80–100	200	200–425
Hardness (Shore)	D785	C73, D50–52	C73, D47–53	D45	D55	D55–D56
Impact Str (Izod), ft-lb/in. notch	D256	—	—	—	—	—
Brittleness Temp, F		<−94	<−4	<14	<−148	<−148
Mod of Elast in Flex, 10^5 psi	D747	13-27	12-30	10	43	35-50
Shear Str, 1000 psi		1.6–1.85	1.4-1.7	1	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	10^{17}–10^{19}	10^{17}–10^{19}	10^{17}–10^{19}	$>10^{15}$	$>10^{16}$
Dielec Str (short time), v/mil	D149	480	480	480	480	480
Dielec Const	D150	2.3	2.3	2.3	2.3	2.3
Dissip Factor	D150	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
FABRICATING PROPERTIES						
Bulk Factor		1.6–2.2	1.6–2.2	1.6–2.2	1.6–2.2	1.6–2.2
Injection Molding						
Pressure, 1000 psi		5–22	5–15	2–10	10–15	10–15
Temperature, F		275–650	275–650	250–350	300–500	300–500
Mold Shrinkage, in./in.		0.02–0.05	0.01–0.04	0.01–0.02	0.02–0.05	0.02–0.05
HEAT RESISTANCE						
Vicat Softening Point, F		176–201	176–201	—	215	220–235
CHEMICAL RESISTANCE		Excellent resistance to acids and alkalis at normal temperature, except oxidizing acids such as nitric, chlorosulfonic and fuming sulfuric. Below 122 F, insoluble in organic solvents; at higher temperatures, soluble to varying degrees in hydrocarbons and halogenated hydrocarbons, but insoluble in more polar liquids. Generally, a higher melt index material has greater solubility				
USES		Injection moldings: kitchen utilityware, toys, process tank liners, closures, packages, sealing rings, battery parts. Blow moldings: squeeze bottles for packaging, containers for drugs. Film: wrapping materials for food, clothes, other items. Wire and cable: high frequency insulation, jacketing. Pipe: chemicals handling, irrigation systems, natural gas transmission				

Polyethylenes—Molded, Extruded

Type →		Type III—Higher Density (0.941–0.960)			
		Melt Index 0.2-0.6	**Melt Index 0.1-12.0**	**Melt Index 1.5-5.0**	**Melt Index 0.2-0.9**
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	0.945–0.947	0.950–0.955	0.96	0.96
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.19	0.19	0.19	0.19
Coef of Ther Exp, 10^{-5} per °F	D696	8.3–16.7	8.3–16.7	8.3–16.7	8.3–16.7
Refractive Index	D542	1.51	1.51	1.51	1.51
Spec Ht, Btu/lb/°F		0.53–0.55	0.53–0.55	0.53–0.55	0.53–0.55
Water Absorption (24 hr), %	D570	<0.01	<0.01	<0.01	<0.01
Flammability, ipm	D635	1.0	1.0	1.0	1.0
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	—	—	—	—
Ten Str, 1000 psi	D412	—	2.9–4.0	4.4	4.4
Elongation, %	D412	—	25–400	12–20	25–30
Hardness (Shore)	D785	D65–66	D60–70	D68–70	D68–70
Impact Str (Izod), ft-lb/in. notch	D256	1.5–6	0.4–6.0	1.2–2.5	4.0–14
Brittleness Temp, F		<−76	<−76 to <−170	−100 to −180	−106 to −180
Mod of Elast in Flex, 10^5 psi	D747	85-120	90-125	150	130-150
Shear Str, 1000 psi		—	—	—	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	$>10^{15}$	$>10^{15}$	$>10^{15}$	$>10^{15}$
Dielec Str (short time), v/mil	D149	480	480	480	480
Dielec Const	D150	2.3	2.3	2.3	2.3
Dissip Factor	D150	<0.0005	<0.0005	<0.0005	<0.0005
FABRICATING PROPERTIES					
Bulk Factor		1.6–2.2	1.6–2.2	1.6–2.2	1.6–2.2
Injection Molding					
Pressure, 1000 psi		10–15	10–15	10–15	10–15
Temperature, F		330–530	330–530	330–530	330–530
Mold Shrinkage, in./in.		0.02–0.05	0.02–0.05	0.02–0.05	0.02–0.05
HEAT RESISTANCE					
Vicat Softening Point, F		250	250–260	260[a]	260[a]
CHEMICAL RESISTANCE		Same basic chemical resistance as Types I and II, but better resistance to some specific chemicals			
USES		Refrigerator parts, packaging, structural housing panels, pipe, defroster and heater ducts, sterilizable housewares and hospital equipment, and hoops			

[a] Adapted from method of Karrer, Davis and Dieterich, *Ind. & Engrg. Chem.*, Vol. 2, No. 30, '30.

Polyvinyl Chloride and Copolymers—Molded, Extruded

Type ➡		Polyvinyl Chloride, Polyvinyl Chloride-Acetate			Vinylidene Chloride[a]
		Nonrigid—General	Nonrigid—Electrical	Rigid—Normal Impact	
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.20–1.55	1.16–1.40	1.32–1.44	1.68–1.75
Ther Cond, Btu/hr/sq ft/°F/ft	D325	0.07–0.10	0.07–0.10	0.07–0.10	0.053
Coef of Ther Exp, 10^{-5} per °F	D696	—	—	2.8–3.3	8.78
Refractive Index	D542	—	—	—	1.60–1.63
Spec Ht, Btu/lb/°F	D570	—	—	—	0.32
Water Absorption (24 hr), %	D635	0.2–1.0	0.40–0.75	0.03–0.40	>0.1
Flammability		Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D412	0.004–0.03	0.01–0.03	3.5–4.0[b]	0.7–2.0
Ten Str, 1000 psi	D412	1–3.5	2–3.2	5.5–9	4–8, 15–40
Elong (in 2 in.), %	D638	200–450	220–360	5–25	15–25, 20–30
Hardness (Rockwell)	D785	—	—	R117–120	M50–65
Hardness (Shore)	D676	A50–100	A78–100	D70–85	>A95
Impact Str (Izod notched), ft-lb/in.	D256	Variable	Variable	0.25–1.2	2–8, 0.053
Mod of Elast in Flex, psi	D790	—	—	3.8–5.4 x 10^5	—
100% Modulus, psi		1300–1750	1200–2800	—	—
Flex Str, 1000 psi	D790	—	—	12.5–16	15–17, flexible
Compr Str, 1000 psi	D695	—	—	11–12	—
Compr Yld Str, 1000 psi	D695	—	—	10–11	75–85
Cold Flex Temp, F	D1043	–70 to 0	–7 to +59	—	—
Cold Bend Temp, F		–40 to –4	–49 to –4	—	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	1–700 x 10^{12}	4–300 x 10^{11}	10^{14}–>10^{16}	10^{14}–10^{16}
Dielec Str (short time), v/mil	D149	—	24–500	725–1400	—
Dielec Const (60 cycles)	D150	5.5–9.1	6.0–8.0	2.3–3.7	3–5
Dissip Factor (60 cycles)	D150	0.05–0.15	0.08–0.11	0.020–0.03	0.03–0.15
Loss Factor (60 cycles)	D150	—	1.0–1.2	0.030–0.072	—
FABRICATING PROPERTIES					
Bulk Factor		2.4–2.6	2.4–2.6	2.0–2.4	—
Compression Molding					
Pressure, 1000 psi		0.5–2	0.5–2	>1	0.5–5
Temperature, F		285–350	285–350	275–400	250–350
Injection Molding					
Pressure, 1000 psi		7–15	12–20	>20	10–30
Temperature, F		320–350	325–375	300–375	300–400
Mold Shrinkage, in./in.		0.02–0.05	0.02–0.06	0.001–0.004	0.008–0.012
Extrusion Temp, F		325–400	350–385	—	<375
HEAT RESISTANCE					
Max Rec Svc Temp, F		150–220	140–220	150–165	170–212
Heat Dist Temp, F					
66 Psi	D648	—	—	170–185	190–210
264 Psi	D648	—	—	140–170	130–150
Softening Point, F		—	—	—	240–280
CHEMICAL RESISTANCE		Generally resistant to alkalis and weak acids. Moderately to not resistant to strong acids. Not resistant to ketones and esters; aromatic hydrocarbons produce swelling			Excellent to all acids and most common alkalis[c]
USES		Parts made by molding, high speed extrusion, calendering. Blown extruded film. Vacuum cleaner parts, handlebar grips, doll parts, hair curlers, safety goggle cups, grommets, toy tires, garden hose, and protective garments	Parts made by calendering, extrusion. Insulation and jacketing for: communication and low tension power wire and cable, building wiring, appliance and machine tool cords, and switchboard cable	Parts made by calendering, laminating, molding, extrusion. Fume hoods and ducts, storage tanks, chemical piping, plating tanks, phonograph records. Sheets and shapes for decorative panels, other building uses	Extrusions: gasket rods, valve seats, flexible chemical tubing and pipe, tape for wrapping joints, chemical conveyor belts. Moldings: spray-gun handles, acid dippers, parts for rayon producing equipment

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[a] Where two values or ranges are given, they represent unoriented and oriented forms, respectively.

[b] Modulus of elasticity in compression.

[c] Unaffected by aliphatic and aromatic hydrocarbons, alcohols, esters, etc.

Polyvinyl Alcohol, Butyral and Formal—Molded, Extruded

Material ➜	ASTM	Polyvinyl Alcohol	Polyvinyl Butyral	Polyvinyl Formal
PHYSICAL PROPERTIES				
Specific Gravity	D792	1.21–1.31	1.07–1.20	1.2–1.4
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.46	—	0.089
Coef of Ther Exp, per °F	D696	3.88–6.65 x 10^{-5}	4.4–12.7 x 10^{-5}	3.55–4.27 x 10^{-5}
Refractive Index	D542	1.49–1.53	1.48–1.49	1.5
Specific Heat, Btu/lb/°F		0.3	0.4	—
Transmittance (luminous), %		[a]	85–91	80–90
Water Absorption (24 hr), %	D570	>30	1.0–3.0	0.5–3.0
Flammability	D635	Slow burning	Slow burning	Slow burning
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638	—	3.5–4.0 x 10^5	5-7 x 10^5
Tensile Strength, 1000 psi	D638	1–5	4–8.5	9–11
Elongation (in 2 in.), %	D638	300–600	5–60	5–20
Hardness (Rockwell)	D785	—	L95	M85
Hardness (Shore A)		10–100	—	—
Impact Strength (Izod notched), ft-lb/in.	D256	—	0.74–1.02	0.8–20
Mod of Elast in Flex, psi		—	—	5–6 x 10^5
Flexural Strength, 1000 psi	D790	—	10	17–18
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257	[b]	>10^{14}	—
Dielectric Strength (short time), v/mil	D149	[b]	400	300–600
Dielectric Constant				
60 Cycles	D150	[b]	3.61	3.7
10^6 Cycles	D150	[b]	3.33	3.0
Dissipation Factor				
60 Cycles	D150	[b]	0.0070	0.010
10^6 Cycles	D150	[b]	0.0065	0.023
FABRICATING PROPERTIES				
Compression Molding				
Pressure, 1000 psi		5–15	1–2	1–10
Temperature, F		250–300	320–400	275–325
Injection Molding				
Pressure		—	11–15	14–32
Temperature, F		—	400	325–425
Mold Shrinkage, in./in.		—	—	0.0015–0.0035
HEAT RESISTANCE				
Max Rec Svc Temp, F		—	115	130–165
Heat Dist Temp, F	D648	—	115–140	155–185
CHEMICAL RESISTANCE		Good resistance to organic solvents and petroleum. Attacked by strong acids. Softened or dissolved by weak acids and by alkalis	Resistant to alkalis, aliphatic hydrocarbons, and most oils. Attacked by acids, alcohols, esters and ketones. Butyral used with wider range of solvents than Formal	
USES		Adhesives and binders, textile sizing, coating and sizing for paper, thickening agents. Molded: chemical and oxygen tubing, gaskets and diaphragms. Film: airtight bags, packaging for chemicals	Plasticized form used as interlayer for safety glass. Solution uses: adhesive primer, metal conditioner, cloth waterproofing	Base for electrical insulating enamel with high heat resistance. Metal wire and cable coatings requiring high toughness and adhesion

[a] Transparent to opaque.

[b] Under atmospheric conditions enough water will be absorbed to make most electrical measurements useless.

Acetal, Polycarbonate, Polypropylene, Chlorinated Polyether—Molded, Extruded

Material ➡		Acetal	Polycarbonate	Polypropylene	Chlorinated Polyether
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.425	1.20	0.90–0.91	1.4
Ther Cond, Btu/hr/sq ft/°F/ft		0.13	0.11	0.08	—
Coef of Ther Exp, per °F	D696	4.5×10^{-5}	3.9×10^{-5}	6.2×10^{-5}	4.4×10^{-5}
Specific Heat, Btu/lb/°F		0.35	—	0.46	—
Water Absorption (24 hr), %	D570	0.41	0.3	0.03	0.01
Flammability, ipm	D635	1.1	Self-extinguishing	—	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	D638	—	0.33×10^{5}[a]	1.55×10^{5}	—
Tensile Strength, 1000 psi	D638	10.0	9.0–10.5	5.0	6
Elongation (total), %	D638	15	60–100	500–700	60–160
Hardness (Rockwell)	D785	M94, R120	M70, R118	R85–95	R100
Impact Strength, ft-lb/in.					
Notched	D256	1.4	12–16	1.02	0.4
Unnotched	D256	—	>60	>17	>33
Mod of Elast in Flex, psi	D790	4.1×10^{5}	3.8×10^{5}	1.7×10^{5}[b]	1.3×10^{5}
Flexural Strength, 1000 psi	D790	14.1	11–13	8.1[b]	5
Stiffness in Flex, 1000 psi	D790	—	—	114–142	—
Compressive Strength, 1000 psi	D695	5.2	11	—	—
Shear Strength, 1000 psi	D732	9.5	9.2	—	—
Yield Strength, 1000 psi	D638	—	8.0–9.0	4.3–4.9	—
Elongation (at yield), %	D638	—	5	10–20	—
ELECTRICAL PROPERTIES					
Volume Resistivity, ohm-cm	D257	$>4 \times 10^{13}$	2.1×10^{16}	$>10^{16}$	5×10^{15}
Dielectric Strength (short time), v/mil	D149	500	400	769–820	400
Dielectric Constant					
60 Cycles	D150	3.7	3.17	—	3.1
10^6 Cycles	D150	3.7	2.96	2.0–2.1	2.8
Dissipation Factor					
60 Cycles	D150	0.004	0.0090	—	0.016
10^6 Cycles	D150	0.004	0.0100	0.0002–0.0003	0.01
Arc Resistance, sec	D495	129	10–11	—	—
FABRICATING PROPERTIES					
Bulk Factor	D1182	—	1.74	2.25	—
Injection Molding					
Pressure, 1000 psi		15–25	15–20	Wide range	10–20
Temperature, F		380–440	550–600	Wide range	440–465
Extrusion Temp, F		—	—	340–430	360–450
Mold Shrinkage, in./in.		0.01–0.04	0.005–0.007	0.015–0.030	0.004–0.006
HEAT RESISTANCE					
Max Rec Svc Temp, F		185	—	—	—
Heat Dist Temp, F					
66 Psi	D648	338	283–293	221	300
264 Psi	D648	212	280–290	—	185
Melt Pt (crystalline), F		347	514	330	—
CHEMICAL RESISTANCE		Excellent res to most organic solvents, including aliphatic and aromatic hydrocarbons. Not rec for use with strong acids and alkalis; should be tested for use with dilute acids and weak alkalis. Affected by ultra violet light	Insoluble in aliphatic hydrocarbons, ether and alcohols; partially soluble in aromatic hydrocarbons; soluble in chlorinated hydrocarbons; slowly decomp by alkaline substances. High stability to water and to mineral and organic acids	Res to most acids, alkalis and saline solutions, even at higher temp; res to organic solvents and polar substances. Above 175 F, soluble in such aromatic substances as toluene and xylene, and such chlorinated hydrocarbons as trichloroethylene	Excellent resistance to both inorganic and organic chemicals. Resistant to all inorganic acids except fuming nitric and fuming sulfuric
USES		Appliance parts. Gears, bushings, bearings, and movie projector and typewriter parts	Gears, housings, structural parts, electronic components, telephone accessories	Structural shapes, housewares, electronic equipment, automotive parts	Valves, pump parts, pipe and sheet for high temperature corrosive environments

[a] 212 F. [b] Tinius-Olsen.

Ureas—Molded

Type[a] ➔		1 (alpha cellulose-filled)	2 (cellulose-filled)
PHYSICAL PROPERTIES	ASTM		
Specific Gravity	D792	1.47–1.52	1.52
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.17–0.244	—
Coef of Ther Exp, per °F	D696	1.22–1.50 x 10^{-5}	—
Transmittance (luminous), %		21.8	0
Water Absorption (24 hr), %	D570	0.4–0.8	—
Flammability	D635	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	D638	13–16 x 10^5	—
Tensile Strength, 1000 psi	D638	5–10	—
Elongation (in 2 in.), %	D638	1.0	—
Hardness (Rockwell)	D785	E94–97, M116–120	—
Impact Strength (Izod notched), ft-lb/in	D256	0.24–0.35	0.26–0.275
Flexural Strength, 1000 psi	D790	10–18	10–13
Compressive Strength, 1000 psi	D695	25–38	—
Shear Strength, 1000 psi		11–12	—
ELECTRICAL PROPERTIES			
Volume Resistivity, ohm-cm	D257	0.5–5 x 10^{11}	5–8 x 10^{10}
Dielectric Strength (short time), v/mil	D149	300–400	340–370
Dielectric Constant			
60 Cycles	D150	7.0–9.5	7.2–7.3
10^6 Cycles	D150	6.4–6.9	6.4–6.5
Dissipation Factor			
60 Cycles	D150	0.035–0.043	0.042–0.044
10^6 Cycles	D150	0.028–0.032	0.027–0.029
Loss Factor			
60 Cycles		0.24–0.38	0.30–0.32
10^6 Cycles		0.18–0.22	0.17–0.19
Arc Resistance, sec	D495	80–130	85–110
FABRICATING PROPERTIES			
Bulk Factor		2.4–3.0	2.5
Compression Molding			
Pressure, 1000 psi		2–8	2–5
Temperature, F		275–350	275–320
Mold Shrinkage, in./in.		0.006–0.014	0.007–0.008
HEAT RESISTANCE			
Heat Dist Temp, F	D648	266–280	—
CHEMICAL RESISTANCE		High resistance to organic solvents, oils and greases. Poor resistance to acids and alkalis, depending on concentration	
USES		Such housings as radio, television, business machines, food equipment. Toilet seats, household electrical switches and plugs, buttons and cosmetic containers	Low cost items. Available only in dark color. Especially suited for electric switch plates, wiring devices and electrical parts requiring high arc resistance

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[a] ASTM D705-55.

Plastics Films

Type ➡		Nylon 6	Polypropylene	Polyethylene		
				Type I	Type II	Type III
GENERAL PROPERTIES	ASTM					
Method of Production[a]		Extr	Extr, calndr	Extr, calndr	Extr, calndr	Extr
Forms Available		Sheets, rolls, tapes	Sheets, rolls, tapes	Sheets, rolls, tapes, tubes	Sheets, rolls, tapes	Sheets, rolls, tapes
Clarity[c]		Trp	Trp	Trp, trl, opaque	Trp, trl, opaque	Trp, trl
Min Thickness, in.		0.0005	0.00075	0.00075	0.00075	0.00075
Max Width, in.		60	60	144	60	60
Area Factor, 1000 sq in./lb/mil[d]		24	30.7	30	30	29
PHYSICAL PROPERTIES						
Specific Gravity	D792	1.12	0.90	0.92	0.935–0.938	0.940–0.945
Ten Str, 1000 psi	D882	13.8–17.0	5–10	1.6–3.0	2.5–3.5	3.5–8.0
Elong, %	D882	>200	>200	200–800	>200	50–400
Burst Str (Mullen), psi[e]	D774	—	—	48	—	—
Tear Str (Elmendorf), gm/mil	D689	50	32–1760	100–300	93–97	10–350
Fold Endurance[e]	D643	Excellent	Excellent	Good	Good	Good
Heat Sealing Range, F[f]		400–450	325–350	250–375	250–375	250–375
Water Absorp (24 hr), %	D570	1.0–1.5	0.005 Max	Negligible	Negligible	Negligible
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	0.9–1.0 (1 mil)	0.06–0.10 (1 mil)	1.2–1.4 (1 mil)[o]	0.5–0.7 (1 mil)[o]	0.3–0.4 (1 mil)[o]
Gas Perm, cu cm/100 sq in./24 hr[e]						
Oxygen		6.5 (1 mil)	140 (1 mil)	550 (1 mil)	280 (1 mil)	200 (1 mil)
Nitrogen		—	—	180 (1 mil)	—	42 (1 mil)
Carbon Dioxide		—	—	2900 (1 mil)	990 (1 mil)	580 (1 mil)
CHEMICAL RESISTANCE						
Strong Acids	D543 or D1239	Poor	Excellent	Excellent[j]	Excellent[j]	Excellent[j]
Strong Alkalis		Excellent	Excellent	Excellent	Excellent	Excellent
Greases and Oils		Excellent	Very good	Fair	Fair	Fair
Solvents						
Ketone and Ester		Excellent	—	Good	Good	Good
Chlorinated		—	—	Fair	Fair	Fair
Hydrocarbon		Excellent	Very good	Fair	Fair	Fair
PERMANENCE						
Max Cont Svc Temp, F		380	300	200	230	250
Min Svc Temp, F		<−100	—	−68	<−100	<−100
Resistance to Sunlight		Fair	Fair	Fair	Fair	Fair
Dimensional Change, %		Nil	Nil	Nil	Nil	Nil
Storage Stability[k]		Excellent	Excellent	Excellent	Excellent	Excellent
Flammability (rate of burning)		Self extinguishing	Slow	Slow	Slow	Slow

[a] Cast = casting; calndr = calendering; extr = extrusion; block = block process.

[b] ASTM D568.

[c] Trp = transparent; trl = translucent.

[d] Figures may vary with resin-plasticizer ratio.

[e] Properties particularly dependent on thickness.

[f] Unsupported film cannot be sealed on all types of heat sealers, since adhesion to meta sealer and distortion of film may be encountered.

[g] ASTM D643, Method A.

[j] Except nitric, fuming sulfuric and chlorosulfonic.

[k] Average warehouse conditions: 400–100 F, dry.

[l] Coating attacked.

[n] ASTM D643, Method B.

[o] At 95 F, 90% RH.

Plastics Films

Type ➡		Rigid Polyvinyl Chloride (incl copolymers)	Nonrigid Polyvinyl Chloride (incl copolymers)	Polyvinylidene Chloride (Saran)	PVC-Nitrile Rubber Blend	Polyvinyl Alcohol
GENERAL PROPERTIES	ASTM					
Method of Production[a]		Cast, calndr, extr	Cast, calndr, extr	Extr	Cast, calndr, extr	Cast
Forms Available		Sheet, rolls, tapes	Sheet, rolls, tapes, tubes	Rolls, tubes	Sheet, rolls, tapes, tubes	Rolls
Clarity[c]		Trp, trl, opaque	Trp, trl, opaque	Trp, trl, opaque	Trp, trl, opaque	Trp, trl
Min Thickness, in.		0.001	0.0005	0.0005	0.001	0.001
Max Width, in.		54	104	40	84	54
Area Factor, 1000 sq in./lb/mil[d]		19.5-22.5	20-23	16.3	22.8-23.7	21.6
PHYSICAL PROPERTIES						
Specific Gravity	D792	1.36-1.50	1.15-1.50	1.68	1.18-1.35	1.21-1.31
Ten Str, 1000 psi	D882	6.5-8.5	1-5	7-15	1.5-4.0	6-10
Elong, %	D882	5-25	50-500	25-40	250-500	400-600
Burst Str (Mullen), psi[e]	D774	—	9-20	30-70	—	185-235
Tear Str (Elmendorf), gm/mil	D689	20-150	30-1400	30	100-960	500-800
Fold Endurance[e]	D643	Poor	Good	500,000[g]	Excellent	Good
Heat Seal Temp Range, F[f]		260-400	200-400	285	220-350	300-400
Water Absorp (24 hr), %	D570	Negligible	Negligible	Negligible	Negligible	> 30
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	0.5 (0.005 in.) to 2.5 (0.001 in.)	0.7 (0.005 in.) to 8.0 (0.001 in.)	0.20	7.0	> 10
Gas Perm, cu cm 100 sq in./24 hr[5]						
Oxygen		3 (0.005 in.) to 15 (0.001 in.)	50-30[m]	0.56[m]	—	—
Nitrogen		—	—	0.11[m]	—	—
Carbon Dioxide		11 (0.005 in.) to 55 (0.001 in.)	250-2000[m]	2.4[m]	—	—
CHEMICAL RESISTANCE						
Strong Acids	D543 or D1239	Excellent	Excellent	Excellent[h]	Good	Poor
Strong Alkalis		Excellent	Excellent	Good[i]	Good	Poor
Greases and Oils		Good	Fair	Excellent	Excellent	Excellent
Solvents						
Ketone and Ester		Poor	Poor	Fair	Poor	Excellent
Chlorinated		Fair	Fair	Fair	Fair	Excellent
Hydrocarbon		Excellent	Good	Excellent	Good	Excellent
PERMANENCE						
Max Cont Svc Temp, F		200-220	150-180	290	200	—
Min Svc Temp, F		-70	-50	Good	-40	—
Resistance to Sunlight		Good	Good	Excellent	Fair	Excellent
Dimensional Change, %		Nil	Nil	Nil	Nil	High
Storage Stability[k]		Excellent	Excellent	Excellent	Excellent	Excellent
Flammability (rate of burning)		Self-extinguishing	Slow to self-extinguishing	Self-extinguishing	Slow to self-extinguishing	Slow

[a] Cast = casting; calndr = calendering; extr = extrusion; block = block process.

[c] Trp = transparent; trl = translucent.

[d] Figures may vary with resin-plasticizer ratio.

[e] Properties particularly dependent on thickness.

[f] Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.

[g] ASTM D643, Method A.

[h] Except sulfuric and nitric.

[i] Except ammonium hydroxide.

[k] Average warehouse condition: 40-100 F, dry

[m] 0.001-in. film.

continued on next page

Plastics Films

Type ➔		Polytetra-fluoro-ethylene	Polytri-fluoromono-chloro-ethylene	Polystyrene (oriented)	Polyester (polyethylene terephthalate)	Rubber Hydrochloride	Ethyl Cellulose
GENERAL PROPERTIES	ASTM						
Method of Production[a]		Block	Extr	Extr	Extr	Cast	Cast, block, extr
Forms Available		Sheet, tapes	Sheet, tubes	Sheet, rolls	Sheet, rolls	Sheet, rolls, tapes	Sheet, rolls, tapes
Clarity[c]		Trp	Trp, trl	Trp, trl, opaque	Trp, opaque	Trp, trl, opaque	Trp
Min Thickness, in.		0.002	0.002	0.001	0.00025	0.0004	0.003
Max Width, in.		12	20	40	55	60	30
Area Factor, 1000 sq in./lb/mil[d]		13	12	26.1	20	24	24
PHYSICAL PROPERTIES							
Specific Gravity	D792	2.15	2.11	1.05-1.07	1.39	1.12-1.15	1.14-1.16
Ten Str, 1000 psi	D882	2-3	6.3-6.6	7-12	17-28	5-6	6-10
Elong, %	D882	200-250	90-200	3-10	70-130[m]	350-500	20-35
Burst Str (Mullen), psi[e]	D774	—	42	30-60	45[m]	—	30-86
Tear Str (Elmendorf), gm/mil	D689	—	200-350	2-8	18	1000-1500	2-15
Fold Endurance[e]	D643	—	—	—	Excellent	10^4-10^6	2700
Heat Seal Range, F[f]		Not heat sealable	415-450	220-300	490	225-350	—
Water Absorp (24 hr), %	D570	None	None	0.04-0.06	Negligible	Negligible	Low
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	—	0.00	6.2	1.8[m]	0.5-15.5	10-50
Gas Perm, cu cm/100 sq in./24 hr[e]							
Oxygen		—	0.76[m]	213	5.7[m]	2-405	—
Nitrogen		—	5.5[m]	42	0.9[m]	—	—
Carbon Dioxide		—	8.0[m]	926	17.5[m]	36-2616	—
CHEMICAL RESISTANCE							
Strong Acids	D543 or D1239	Excellent	Excellent	Good	Excellent	Good	Poor
Strong Alkalis		Excellent	Excellent	Excellent	Excellent	Good	Excellent
Greases and Oils		Excellent	Excellent	Good	Excellent	Excellent	Good
Solvents							
Ketone and Ester		Excellent	Excellent	Poor	Excellent	Fair	Poor
Chlorinated		Excellent	Excellent	Good	Excellent	Fair	Poor
Hydrocarbon		Excellent	Excellent	Good	Excellent	Excellent	Fair
PERMANENCE							
Max Cont Svc Temp, F		565-585	300-395	160-180	490	205	210-275
Min Svc Temp, F		-90	-120	Good	-80	-20	-75
Resistance to Sunlight		Excellent	Excellent	Fair	Fair	Fair	Good
Dimensional Change, %		Nil	Nil	Nil	Nil	Slight	Slight
Storage Stability[k]		Excellent	Excellent	Good	Excellent	Good	Excellent
Flammability (rate of burning)		Nil	Nil	Slow	Self-extinguishing	Self-extinguishing	Slow

[a] Cast = casting; calndr = calendering; extr = extrusion; block = block process.

[c] Trp = transparent; trl = translucent.

[d] Figures may vary with resin-plasticizer ratio.

[e] Properties particularly dependent on thickness.

[f] Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.

[k] Average warehouse conditions: 40-100 F, dry.

[m] 0.001-in. film.

Plastics Films

Type →		Cellophane		Cellulose			
		Plain	Coated	Acetate[m]	Triacetate (42.5-44% acetyl)	Acetate Butyrate[m]	Nitrate
GENERAL PROPERTIES	ASTM						
Method of Production[a]		Extr	Extr	Extr, cast	Cast	Extr, cast	Cast, block
Forms Available		Sheet, rolls, tapes	Sheet, rolls	Sheet, rolls, tapes, tubes	Sheet, rolls	Sheet, rolls	Sheet, rolls
Clarity[c]		Trp	Trp	Trp, trl, opaque	Trp	Trp, opaque	Trp, trl, opaque
Min Thickness, in.		0.0009	0.0009	0.0005	0.003	0.0009	0.0005
Max Width, in.		60	60	60	45	40	50
Area Factor, 1000 sq in./lb/mil[d]		21.5	19.5	22	21.7	23.3	20
PHYSICAL PROPERTIES							
Specific Gravity	D792	1.45	1.40-1.55	1.25-1.35	1.28	1.16-1.18	1.42-1.46
Ten Str, 1000 psi	D882	8-19	7-16	9-14	9-11	6-9	10-11
Elong, %	D882	15-25	15-50	15-35	25-35	50-70	30-40
Burst Str (Mullen), psi[e]	D774	—	—	30-80	100-150	40-75	40-50
Tear Str (Elmendorf), gm/mil	D689	2-10	2-15	2-15	10-15	4-16	—
Fold Endurance[e]	D643	7000-22,000	—	1500-2000[n]	200-300[n]	900-1300[n]	50-250[g]
Heat Sealing Range, F[f]		Not heat sealable	200-350	400-500	—	—	—
Water Absorp (24 hr), %	D570	High	High	Low	Low	Low	Low
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	High	0.2-1.0	10-40	10	60	—
Gas Perm, cu cm/100 sq in./24 hr[e]							
Oxygen		—	Low	3-6	—	—	—
Nitrogen		—	Low	—	—	—	—
Carbon Dioxide		—	Low	12-31	—	—	—
CHEMICAL RESISTANCE							
Strong Acids	D543 or D1239	Poor	Poor	Poor	Poor	Poor	Good
Strong Alkalis		Poor	Poor	Poor	Poor	Poor	Fair
Greases and Oils		Excellent	Good[l]	Good	Good	Fair	Fair
Solvents							
Ketone and Ester		Excellent	Poor[l]	Poor	Poor	Poor	Poor
Chlorinated		Excellent	Excellent	Poor	Poor	Poor	Fair
Hydrocarbon		Excellent	Fair	Good	Good	Good	Fair
PERMANENCE							
Max Cont Svc Temp, F		375	300-375	250-300	300-400	200-250	140
Min Svc Temp, F		0	0	−25	−25	−25	—
Resistance to Sunlight		Good	Good	Good	Good	Good	Poor
Dimensional Change, %		3-5	2-5	0.2-0.8	0.4	0.3	Nil
Storage Stability[k]		Good	Good	Excellent	Excellent	Excellent	Fair
Flammability (rate of burning)		Fast	Fast	Slow, 70-100[b]	Self-extinguishing	Slow, 50-80[b]	Fast

[a] Cast = casting; calndr = calendering; extr = extrusion; block = block process.

[b] ASTM D 568.

[c] Trp = transparent; trl = translucent.

[d] Figures may vary with resin-plasticizer ratio.

[e] Properties particularly dependent on thickness.

[f] Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.

[g] ASTM D 643, Method A.

[k] Average warehouse conditions: 40-100 F, dry.

[l] Coating attacked.

[n] ASTM D 643, Method B.

High Pressure Laminates (General Purpose)—Sheet, Rod, Tube

Grade →	CE (canvas-phenolic)	A (asbestos paper-phenolic)	AA (asbestos cloth-phenolic)	G-3 (glass cloth-phenolic)
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.32	1.72	1.70	1.65
Ther Cond, Btu/sq ft/hr/°F/ft	0.17	—	—	—
Max Rec Svc Temp, F				
Short Time	300	400	400	410
Continuous	250	275	275	290
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	0.58	0.31	0.58	0.52
Crosswise	0.68	0.49	0.58	0.62
Water Absorption (24 hr), %				
1/16 In. Thick	1.3	1.3	2.5	1.8
1/8 In. Thick	0.9	0.8	2.0	1.2
1/2 In. Thick	0.5	0.5	1.2	0.7
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	11	10	12	23
Crosswise	9	8	10	20
Flex Str, 1000 psi				
Lengthwise	22	20	21	32
Crosswise	17	18	19	28
Compr Str (flatwise), 1000 psi	39	40	38	50
Mod of Elast in Flex, 10^5 psi				
Lengthwise	9	23	16	15
Crosswise	8	14	14	12
Impact Str (edgewise), ft-lb/in.				
Lengthwise	1.6	1.0	4.5	7.5
Crosswise	1.4	0.9	4.0	6.0
Hardness (Rockwell)	M105	M111	M103	M120
Bond Strength, psi	2200	800	2000	1000
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	500	225	85	700
1/8 In. Thick	360	160	70	600
Dielec Str (par., step by step, 1/8 in. thick), kv				
Cond A	45	10	—	—
Cond D48/50	5	—	—	—
Dissip Factor (10^6 cycles)				
Cond A	0.055	—	—	0.030
Cond D24/23	0.070	—	—	—
Dielec Const (10^6 cycles, cond A)	5.3	—	—	6.5
Insulation Res (cond 35/90), megohms	—	—	—	200
Arc Resistance, sec	10	10	10	10
AIEE Insulation Class	A	B	B	B
USES	Switchboard panels, circuit breaker and switch arms, terminal blocks, electrode supports for plating tanks, bases for motors, bobbin heads (often in combination with XX)	Mechanical parts in drying ovens, tenter rails	Rotor vanes, water pumping thrust washers, armature slot wedges, caustic resistant applications, electric appliance insulation	Armature slot wedges, structural parts requiring good electrical properties, electrical equipment operating at relatively high temperatures

High Pressure Laminates (General Purpose)—Sheet, Rod, Tube

Grade ➜	**G-5** (glass cloth-melamine)	**G-10** (glass cloth-epoxy)	**GPO-1** (glass mat-polyester)	**Commercial and Trunk Fibre**
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.9	1.78	1.5–1.9	1.15
Ther Cond, Btu/sq ft/hr/°F/ft	0.29	—	—	—
Max Rec Svc Temp, F				
Short Time	425	350	350	—
Continuous	300	250	250	—
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	0.31	—	1.1	—
Crosswise	0.34	—	—	—
Water Absorption (24 hr), %				
1/16 In. Thick	1.0	0.09	1.0	66
1/8 In. Thick	0.6	0.06	0.70	61
1/2 In. Thick	0.4	0.03	0.35	36
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	37	—	12	7.5
Crosswise	30	—	10	5.5
Flex Str, 1000 psi				
Lengthwise	65	72	23	14
Crosswise	50	63	20	12
Compr Str (flatwise), 1000 psi	70	—	40	20
Mod of Elast in Flex, 10^5 psi				
Lengthwise	17	—	15	—
Crosswise	15	—	13	—
Impact Str (edgewise), ft-lb/in.				
Lengthwise	12.0	14.4	12	3.5
Crosswise	9.0	10.6	10	2.9
Hardness (Rockwell)	M120	—	M100	R50
Bond Strength, psi	1700	2500	1000	1000
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	350	810	650	175
1/8 In. Thick	260	570	500	150
Dielec Str (par., step by step, 1/8 in. thick), kv				
Cond A	32	55	60	—
Cond D48/50	12	60	33	—
Dissip Factor (10^6 cycles)				
Cond A	0.016	0.0119	0.03	0.024
Cond D24/24	0.030	0.0126	0.06	0.030
Dielec Const (10^6 cycles, cond A)	6.8	4.8	4.3	—
Insulation Res (cond C96/35/90), megohms	100	1 x 10^5	—	—
Arc Resistance, sec	200	17	100	100
AIEE Insulation Class	B	B	B	—
USES	Switchboard panels, arc barriers and circuit breaker parts, armature and slot wedges, structural parts, electrical applications requiring high strength and arc resistance, high temperature applications	Printed circuits; other applications where high insulation resistance and dimensional stability, are required.	Panel boards, slot wedges, spacers, coil blocking, layer insulation, core corner protectors, terminal plates, structural applications	Washers, terminal block covers, insulating plates and switch covers, arch supporters, bobbin and coil spool heads, arc barriers, shoe fiber, switch and appliance insulation, knee pads, golf club head plates, deep formed parts, trunks, cases, wastebaskets, mill boxes

High Pressure Laminates (Mechanical)—Sheet, Rod, Tube

Grade →	X (kraft paper-phenolic)	P (paper-plasticized phenolic)	PC (paper-phenolic)	ES 1, 2, 3 (paper base)[a]
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.35	1.33	1.34	—
Ther Cond, Btu/hr/sq ft/°F/ft	0.17	0.17	0.17	—
Max Rec Svc Temp, F				
Short Time	275	275	250	—
Continuous	225	250	200	—
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	0.61	0.43	—	—
Crosswise	0.77	0.68	—	—
Water Absorption (24 hr), %				
1/16 In. Thick	4.0	2.2	3.2	2.5
1/8 In. Thick	2.3	1.5	2.0	1.8
1/2 In. Thick	0.9	—	—	—
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	20	12	10.5	12-15
Crosswise	16	9	8.5	8-12
Flex Str, 1000 psi				
Lengthwise	28	15	14	15
Crosswise	23	13	11	15
Compr Str (flatwise), 1000 psi	36	25	22	—
Mod of Elast in Flex, 10^5 psi				
Lengthwise	18	12	10	—
Crosswise	13	9	8	—
Impact Str (edgewise), ft-lb/in.				
Lengthwise	0.9	0.8	0.9	0.25
Crosswise	0.7	0.6	0.8	0.22
Hardness (Rockwell)	M110	M95	M75	M118
Bond Strength, psi	900	—	—	—
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	700	650	600	—
1/8 In. Thick	500	470	425	—
Dielec Str (par., step by step, 1/8 in. thick), kv				
Cond A	—	50	—	—
Cond D48/50	—	10	—	—
Dissip Factor (10^6 cycles)				
Cond A	—	—	—	—
Cond D24/23	—	—	—	—
Dielec Const (10^6 cycles, cond A)	—	—	—	—
Insulation Res (cond C96/35/90), megohms	—	—	—	—
Arc Resistance, sec	10	—	—	—
AIEE Insulation Class	A	A	A	A
USES	Structural parts for radio, aircraft and electrical equipment and switchgear. Terminal boards or panels, insulating washers, bushings, coil forms, brush-holder bushings	Insulating washers, terminal boards, plug and socket bases, switch bases and panels for subassemblies	Motor and generator terminal boards, insulating washers, terminal strips, switch bases and panels, staked terminal boards and strips	Engraved name-plates, signs

[a] ES-1 is melamine laminate; ES-2 is phenolic laminate; ES-3 has phenolic core, melamine base.

High Pressure Laminates (Mechanical)—Sheet, Rod, Tube

Grade ➡	C (cotton canvas-phenolic)	L (cotton linen-phenolic)	MC (cotton fabric-melamine)	Bone Fibre
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.35	1.34	1.5	1.3
Ther Cond, Btu/hr/sq ft/°F/ft	0.17	0.17	0.17	0.17
Max Rec Svc Temp, F				
Short Time	275	275	275	—
Continuous	225	225	225	221
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	0.58	0.43	—	—
Crosswise	0.68	0.58	—	—
Water Absorption (24 hr), %				
1/16 In. Thick	4.4	2.0	2.2	55
1/8 In. Thick	2.5	1.4	1.6	48
1/2 In. Thick	1.2	0.8	1.0	25
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	11	14	11	8
Crosswise	9	10	7	6
Flex Str, 1000 psi				
Lengthwise	22	23	23	15
Crosswise	18	18	18	13
Compr Str (flatwise), 1000 psi	37	35	45	30
Mod of Elast in Flex, 10^5 psi				
Lengthwise	10	11	—	12
Crosswise	9	8	—	8
Impact Str (edgewise), ft-lb/in.				
Lengthwise	2.3	1.3	0.9	3.0
Crosswise	2.2	1.2	0.9	2.4
Hardness (Rockwell)	M103	M105	M115	R80
Bond Strength, psi	2000	1700	1900	—
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	500	500	—	175
1/8 In. Thick	360	360	—	150
Dielec Str (par., step by step, 1/8 in. thick) kv				
Cond A	15	15	—	—
Cond D48/50	—	—	—	—
Dissip Factor (10^6 cycles)				
Cond A	—	0.055	—	—
Cond D24/23	—	0.070	—	—
Dielec Const (10^6 cycles, cond A)	6.0	5.8	—	—
Insulation Res (cond C96/35/90), megohms	—	—	—	—
Arc Resistance, sec	10	10	100	100
AIEE Insulation Class	A	A	—	—
USES	Gears and pinions, cams, pulleys, bobbin heads, chemical piping and fittings, bearings	Small gears and pinions, parts requiring intricate machining, breaker arms, fairleads and knobs	Plating barrel applications; others requiring good resistance to caustics	Gears, cams, fairleads, bushings, grommets, switch handles, terminal blocks, armature slot wedges, threaded and tapped pieces

High Pressure Laminates (Electrical)—Sheet, Rod, Tube

Grade →	XX (paper-phenolic)	XXP (paper-phenolic)	XXX (paper-phenolic)	XXXP (paper-plasticized phenolic)	LE (cotton linen-phenolic)
PHYSICAL PROPERTIES					
Density, gm/cu cm	1.34	1.32	1.32	1.32	1.32
Ther Cond, Btu/hr/sq ft/°F/ft	0.17	0.17	0.17	0.17	0.17
Max Rec Svc Temp, F					
Short Time	300	275	300	275	300
Continuous	250	250	250	250	250
Coef of Ther Exp, 10^{-5} per °F					
Lengthwise	0.41	0.58	0.41	0.58	0.58
Crosswise	0.74	0.92	0.71	0.92	0.80
Water Absorption (24 hr), %					
1/16 In. Thick	1.3	1.3	0.8	0.40	1.3
⅛ In. Thick	0.9	0.9	0.5	—	0.8
½ In. Thick	0.5	—	0.3	—	0.5
MECHANICAL PROPERTIES					
Ten Str, 1000 psi					
Lengthwise	16	11	15	12	13.5
Crosswise	13	8.5	12	9.5	9.5
Flex Str, 1000 psi					
Lengthwise	18	18	18	21	18
Crosswise	14	14	14	15	15
Compr Str (flatwise), 1000 psi	34	25	32	25	37
Mod of Elast in Flex, 10^5 psi					
Lengthwise	14	9	13	11	10
Crosswise	11	7	10	8	8
Impact Str (edgewise), ft-lb/in.					
Lengthwise	0.55	0.55	0.5	0.6	1.3
Crosswise	0.50	0.50	0.45	0.5	1.2
Hardness (Rockwell)	M105	M100	M110	M112	M105
Bond Strength, psi	1100	—	1200	—	1800
ELECTRICAL PROPERTIES					
Dielec Str (perp, short time), v/mil					
1/16 In. Thick	700	700	650	650	500
⅛ In. Thick	500	500	470	470	360
Dielec Str (par., step by step, ⅛ in. thick), kv					
Cond A	50	65	65	65	50
Cond D48/50	10	15	15	33	6
Dissip Factor (10^6 cycles)					
Cond A	0.040	0.037	0.034	0.030	0.048
Cond D24/23	0.046	0.045	0.038	0.035	0.058
Dielec Const (10^6 cycles, cond A)	5.3	4.5	4.7	4.27	5.3
Insulation Res (cond C96/35/90), megohms	60	500	1000	20,000	30
Arc Resistance, sec	10	10	10	10	10
AIEE Insulation Class	A	A	A	A	A
USES	Panels for switchboards and instruments, switch and circuit breaker arms, terminal blocks for motors and transformers, coil forms for radio and television, brush holder bushings, bobbin heads and spools	Condenser stator brackets, wave change switch rotors and stators, plug and socket bases, terminal boards and subpanels, insulating washers	Panels for radio and television equipment; jack spacers, radio coil forms, high voltage switchgear	Condenser stator brackets, wavechange switch rotors and stators, terminal boards and subpanels, coil support bases	Terminal blocks and strips, panels, high humidity applications

High Pressure Laminates (Electrical)—Sheet, Rod, Tube

Grade ➜	G-2 (glass cloth-phenolic)	G-6 (glass cloth-silicone)	G-7 (glass cloth-silicone)	N-1 (nylon fabric-phenolic)	**Electrical Insulation Fibre**
PHYSICAL PROPERTIES					
Density, gm/cu cm	—	1.65	1.68	1.15	1.15
Ther Cond, Btu/hr/sq ft/°F/ft	—	0.17	0.17	—	—
Max Rec Svc Temp, F					
Short Time	410	500	500	200	—
Continuous	290	400	400	165	—
Coef of Ther Exp, 10^{-5} per °F					
Lengthwise	—	0.31	—	—	—
Crosswise	—	0.31	—	—	—
Water Absorption (24 hr), %					
1/16 In. Thick	1.50	0.3	0.3	0.3	66
1/8 In. Thick	0.95	0.25	0.20	0.2	61
1/2 In. Thick	0.55	0.15	0.15	0.1	36
MECHANICAL PROPERTIES					
Ten Str, 1000 psi					
Lengthwise	16	13	23	8.5	7.5
Crosswise	11	10	18	8	5.5
Flex Str, 1000 psi					
Lengthwise	30	23	44	18	—
Crosswise	20	19	37	15	—
Compr Str (flatwise), 1000 psi	38	40	45	—	32
Mod of Elast in Flex, 10^5 psi					
Lengthwise	13	—	14	6	—
Crosswise	10	—	12	5	—
Impact Str (edgewise), ft-lb/in.					
Lengthwise	6.6	15.1	12.1	3.7	—
Crosswise	4.7	9.5	9.6	3.3	—
Hardness (Rockwell)	M110	M95	M100	M105	—
Bond Strength, psi	1400	1000	800	1200	—
ELECTRICAL PROPERTIES					
Dielec Str (perp, short time), v/mil					
1/16 In. Thick	500	250	400	600	175
1/8 In. Thick	425	185	350	450	175
Dielec Str (par., step by step, 1/8 in. thick), kv					
Cond A	30	50	55	62	—
Cond D48/50	10	45	30	55	—
Dissip Factor (10^6 cycles)					
Cond A	0.025	0.0022	0.0015	0.024	—
Cond D24/23	0.080	0.0227	0.0150	0.030	—
Dielec Const (10^6 cycles, cond A)	5.5	4.18	3.9	3.3	—
Insulation Res (cond C96/35/90), megohms	5000	4000	2500	5×10^4	—
Arc Resistance, sec	—	220	220	—	100
AIEE Insulation Class	B	H	H	A	A
USES	Class B insulation; other applications where good temperature resistance is required but mechanical properties are not critical	Insulation applications where high temperature resistance, arc resistance and low losses are needed, such as Class H transformers	Radio transmitter parts; Class H transformers; low loss, high frequency radio and radar insulators; motor slot wedges; slot liners; top sticks	High voltage applications; radio wave change switch stators and rotors, where low losses are critical; electrical insulating parts that must be postformed	Armature slot insulation, armature end laminations, field coil insulation, metal box liners, washers, arc shields, formed slot wedges, gaskets, specialties

Glass-Reinforced Plastics (Low Pressure)—Molded Laminates [a]

Type ➡		Polyester (rigid styrene type)		Silicone–Woven Fabric	Epoxy–Woven Fabric
		Mat	Woven Fabric		
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.15–2.2	1.6–2.0	1.6–1.93	1.6–1.85
Coef of Ther Exp, 10^{-5} per °F	D325	1.0–1.4	—	—	—
Water Absorption (24 hr), %	D570	0.1–2.0	0.1–0.8	0.03–0.1	0.04–0.08
Flammability (<0.050 in.), sq in./min	D635	2.0 to self-exting	1.0 to self-exting	0–120[c]	—
MECHANICAL PROPERTIES					
Ten Str, 1000 psi	D638	8–25	25–55	20–40.6[d]	40–85
Hardness					
Rockwell	D785	M80–120	M100–120	—	M100–112
Barcol		40–55	55–65	50–75	62–66
Impact Str (Izod), ft-lb/in. notch	D256	7–15	13–18	—	12–18
Mod of Elast in Flex, 10^5 psi	D790	10–25	20–38	18–32[d]	30–46
Flex Str, 1000 psi	D790	20–40	40–75	23–47[d]	65–120
Compr Str, 1000 psi	D695	15–35	25–45	9.3–24[d]	45–52
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{11}	10^{11}	2.4–14 x 10^{14}	10^{16}
Dielec Str (short time, ⅛ in.), v/mil	D149	300–800	350–700	100–388	450–550
Dielec Const					
60 Cycles	D150	3.4–6.0	4.1–6.0	—	—
1000 Cycles	D150	3.4–5.8	4.0–5.8	—	—
10^6 Cycles	D150	3.4–5.6	3.8–5.6	3.5–3.97	4.2–4.9
Dissip Factor (10^6 cps)	D150	0.01–0.03	0.01–0.03	0.001–0.003	—
Loss Factor					
60 Cycles	D150	0.1–0.3	0.08–0.3	—	—
1000 Cycles	D150	0.07–0.3	0.06–0.3	—	—
10^6 Cycles	D150	0.03–0.2	0.03–0.2	—	0.05–0.09
Arc Resistance, sec	D495	90–130	90–180	225–250	130–185
HEAT RESISTANCE					
Max Rec Svc Temp, F		250–400	250–400[b]	450–500	250–400
Heat Dist Temp (264 psi), F	D648	200–550	390–550	—	—
CHEMICAL RESISTANCE		Slightly to heavily attacked by strong acids. Attacked by strong alkalis, ketones and chlorinated solvents		Satisfactory resistance to aviation gas, lube oils, 40% sulfuric acid, 5% hydrochloric acid, and Freon 114. Slightly attacked by 5% hydrochloric acid. Severely attacked by acetone, methyl ethyl ketone, ethyl alcohol, isopropyl ether, toluene, cellosolve, carbon tetrachloride, ethylene dichloride and trichlorethylene	Excellent resistance to organic liquids, such as alcohols and hydrocarbons. Resistant to weak acids and some strong acids. Slightly affected by some strong alkalis. Relatively poor general resistance to acetone, glacial acetic acid, 30% nitric acid and 30% peroxide
USES		Either mat, cloth or combination of both used, depending on strength and economic requirements. Represents largest volume of all low pressure reinforced plastics. Used for boats, car bodies and parts, aircraft parts, chairs, trays, skis, tote boxes, laundry tubs, machine housings, chemical storage tanks, architectural building panels		Special high temperature structural or electrical parts, such as aircraft radomes and ductwork, thermal and arc barriers, covers and cases for high frequency equipment	High strength parts, such as laminated tools for metal forming, aircraft structural parts, pipe, leaf or coil springs, high strength electrical or chemical resistant parts

[a] Range of values is intended only to indicate general order of magnitude. Specific properties vary widely with type and quantity of reinforcement resin formulation and fabricating practice.

[b] A TAC-polyester is now available for continuous use at 500 F.

[c] When tested according to Method 2023 of Spec. MIL L–P–406.

[d] A primary attribute of silicones is good strength retention after continuous exposure to 450–500 F.

Plastics and Rubber Foams—Flexible

NATURAL RUBBER (LATEX)

Density, lb/cu ft	6.0–7.0
Ther Cond, Btu/hr/sq ft/°F/ft	0.021–0.025
Tensile Strength, psi	10–20
Max Rec Svc Temp, F	160
Flammability	Burns
Tear Strength, lb/in.	1.2
Resilience, %	64
Rebound, in.	2.5
Elongation, %	380
Compression Loss, %	
50,000 Flexes	13.0
300,000 Flexes	15.0
Compression Set, %	
22 Hr at 158 F	4.6
22 Hr at 177 F	4.1
Hysteresis Loss, %	23.2
RMA Compression, lb	30.0

POLYETHYLENE (CELLULAR)[a]

Tensile Strength	670
Elongation, %	310
Specific Gravity	0.47
Dielectric Strength, v/mil	
Short Time	220
Long Time	190
Dissipation Factor	
1000 Cycles	0.00033
10,000 Cycles	0.00038
Dielectric Constant	
1000 Cycles	1.48
10,000 Cycles	1.49

[a] Wire insulation for No. 14 AWG (0.250-in. o. d.). Wire insulation is the primary use of cellular polyethylene at present.

VINYL (OPEN CELL)

Density, lb/cu ft	4 and up
Heat Sealability	Excellent
Tensile Strength, psi	10–200
Elongation, %	75–300
Flammability	Self-extinguishing
Indentation Load Deflection (25% def)	
Original, lb/50 sq in.	3–500
After Aging, % chg[a]	±20
Compression Set (max, 2 hr at 158 F), %	15
Set after Dynamic Flexing (max, 250,000 cycles), %	10
Chemical Resistance[b]	
Strong Acids	E
Strong Alkalis	E
Grease, Oils	G
Organic Solvents	P to E
Water	E
High Humidity	E
Sunlight	G

[a] Air oven aging 22 hr, 212 F.
[b] E = excellent; G = good; P = poor.

SYNTHETIC RUBBERS

Type →	Neoprene	Butadiene-Styrene (GR-S)	Butadiene-Acrylonitrile
Density, lb/cu ft	10–30	4.5	10–25
Ther Cond, Btu/hr/sq ft/°F/ft	0.021–0.029	0.018	0.021–0.025
Tensile Strength, psi	20–100	80	40
Max Rec Svc Temp, F	180	160	210

URETHANES

Density[a] →	1	2-4	6-8	10-12	16-20
Yld Str (0.2% offset), psi	2.5	4–20	50–75	200	—
Compr Str (50% defl), psi	5	9–48	78–150	200–380	—
Coef of Ther Exp (−22 to 86 F) 10^{-5} per °F	—	1.4	—	—	5
Ther Insulation Coef (K)	0.20	0.20–0.21	0.22–0.23	0.26	0.28–0.30
Water Absorption, lb/cu ft					
25-Day Soak	28	22.8–24	—	—	2–4
120 Hr at 50% RH	0.005	0.006–0.027	—	—	0.067–0.084
120 Hr at 98% RH	0.38	0.38–0.39	—	—	0.359–0.560
Dielec Const (1000 cycles)	—	2.2–2.3	—	2.5	2.70–2.85
Vol Res, 10^{14} ohm-cm	—	6.8–6.9	—	7.2	7.7–8.3
Sound Absorption Coef					
250 Cycles	—	0.73	0.20	0.22	—
500 Cycles	—	0.33	0.22	0.21	—
1000 Cycles	—	0.37	0.20	0.31	—
Bond Str, psi					
Aluminum	6	10–27	—	56	158
Glass	5	9–25	—	50	142
Steel	7	12–29	—	62	146
Wood	8	17–29	—	62	170
Flame Res [b]					
2 Lb/Cu Ft	Incombustible				
10 Lb/Cu Ft	Self-extinguishing				
Max Rec Svc Temp, F	200				
Heat Dist Temp (5 psi flex, 0.10 in. defl), F	130				
Chemical Res	Swell slightly in many chemical solutions. Attacked by strong acids and alkalis				

[a] Density in lb per cu ft.
[b] Federal Bldg Spec SSA118A.

Plastics Foams—Rigid

SILICONES

Density[a] ➡	12[b]	14[b]	16[c]
Compr Str (orig), psi	100	200	325
Compr Str (after aging), psi[d]			
77 F, 200 Hr	100	190	210
500 F, 1/2 Hr	5	25	70
500 F, 200 Hr	20	45	80
Weight Loss During Expansion, %	1.2	1.3	1.0
Weight Loss After Heating, %			
1000 Hr, 500 F	3.5	2.6	2.6
1000 Hr, 570 F	8.0	4.2	4.2
72 Hr, 700 F	8.5	5.2	5.2
Water Abs (24 hr), %	3.2	2.3	2.1
Heat Dist Temp, F	>700	>700	>700
Flammability	No burn	No burn	No burn
Dielec Const (10^5 cycles)	1.23	1.25	1.26
Dissip Factor (10^5 cycles)	0.0004	0.00102	0.00105
Ther Cond, Btu/hr/sq ft/°F/ft	0.025	0.025	0.025

[a] Density in lb per cu ft.
[b] Expanded at 320 F.
[c] Prefoamed; expanded at 320 F.
[d] Heat aged at 500 F.

POLYSTYRENES AND CELLULOSE ACETATE

Type, Density[a] ➡	Polystyrenes				Cellulose Acetate (prefoamed)
	Prefoamed		Foam-in-Place		
	1.3-2.0	3.0-4.2	2-4	6-10	4-8
Compr Yld Str, psi	10–35	50–140	15–50[d]	60–100[d]	128–235
Ten Str, psi	30–100	105–185	30–85	90–130	112–183
Shear Str, psi	15–45	55–95	—	—	100–185
Flex Str, psi	>32	<170	40–120	130–310	73–177
Compr Mod of Elast, 1000 psi	0.45–1.75	1.7–5.3	—	—	5.5–13.5
Flex Mod of Elast, 1000 psi	0.20–1.9	—	—	—	3.5–5.5
Impact Str (Izod), ft-lb/in. notch	0.5–2.7	—	2.0–3.0[e]	3.0–5.5[e]	0.01–1.15
Flammability, ipm	Available self-ext		—	—	4.2–8.5
Ther Cond, Btu/hr/sq ft/°F/ft	0.020–0.024		0.018–0.019	0.020–0.023	0.025–0.027
Coef of Ther Exp, per °F	2.5×10^{-5}		—	—	$2.0–2.5 \times 10^{-5}$
Spec Ht, Btu/lb/°F	0.27		—	—	—
Max Rec Svc Temp, F	155–175		185	185	200–350
Water Absorption (vol), %	<6		—	—	0.15, 1.05[b]
Water Vapor Transmission[c]	1.5–3.0		—	—	—
Dielec Const	<1.07		1.19[f]	—	1.10–1.12
Dissip Factor	<0.004		>0.0005[g]	—	0.002–0.003

[a] Density in lb per cu ft.
[b] Absorption in lb per cu ft at 50 and 100% RH, respectively.
[c] Grains/sq ft/hr/in. Hg.
[d] At 5% offset.
[e] Unnotched, in.-lb/in.
[f] At 4–6 lb/cu ft density.
[g] At 2–10 lb/cu ft density.

EPOXIES, PHENOLICS AND URETHANES[a]

Type, Density[b] ➡	**Epoxy** (prefoamed)		**Phenolic** (foam-in-place)		**Urethane** (foam-in-place)			
	5-10	13-20	2-5	7-10	0.5-5	6-9	12-15	18-25
Compr Str, psi	90–260	440–1080	9–31	45–130	2–120	150–250	350–800	900–1800
Ten Str, psi	51–180	360–650	4–35	35–75	10–150	150–300	300–600	700–1200
Flex Str, psi	210–420	570–940	24–40	75–230	—	—	—	—
Shear Str, psi	—	—	8–30	40–135	2–100	120–200	180–550	7600
Ther Cond, Btu/hr/sq ft/°F/ft	0.022	0.024	0.020	0.023	0.01–0.03	0.012–0.03	0.014–0.03	0.015–0.03
Coef of Ther Exp, 10^{-5} per °F	2.2	1.6	—	—	1.5	2.0	4.4	5.0
Water Abs (vol), %	0.25–1.3	0.09–0.1	—	—	—	1.6	0.6	0.2
Max Rec Svc Temp, F	—	—	300[c]	300[c]	250	350	400	400
Flammability	—	—	Noninflammable		Self-extinguishing			
Dissip Factor	0.0001–0.0004	0.003–0.009	—	—	0.0005	0.001	0.002	0.003
Vol Res, ohm-cm	—	—	—	—	—	—	—	—
Dielec Str, v/mil	—	—	—	—	—	—	—	—
Dielec Const	1.19–1.36	1.46–1.55	—	—	1.05	1.15	1.25	1.40

[a] Chemically activated.
[b] Density in lb per cu ft.
[c] For intermittent exposure: 550 F.

Hard Rubber—Molded, Extruded

Type ⇒	Molded Parts[a]								
	GP	GP	GP	GP	H Ht	H Ar	Ar Ht Wr, H DQ	H Ht, Ch	Ht Ma
PHYSICAL PROPERTIES[b]									
Specific Gravity	1.21	1.21	1.28	1.54	1.65	1.95	1.71	1.24	1.80
Water Absorption (24 hr), %	0.08	0.06	0.14	0.30	0.06	0.06	0.10	0.12	0.04
Color	Black	Black	Black	Black	Red-brown	Red-brown	Red-brown	Black	Black
MECHANICAL PROPERTIES									
Ten Str, 1000 psi	8.3	7.9	4.5	2	6.75	4	5.8	7.17	5.4
Elong (in 2 in.), %	4.00	4.00	3.40	2.00	2.60	1.00	2.60	2.70	1.80
Hardness (Rockwell)	B108–76	B107–91	B129–79	B103–27	B83–60	B65–41	B82–55	B115–85	B82–54
Hardness (durometer)	81–87	81–87	78–84	76–82	85–92	87–95	86–92	84–90	84–92
Impact Str (Izod notched), ft-lb/in.	0.48	0.45	0.45	0.27	0.35	0.32	0.38	0.41	0.34
Flex Str, 1000 psi	12.5	11.3	7.1	2.8	8.7	8.4	9.1	11.3	10
Heat Dist Temp, F	142	145	134	Low	283	300	246	275	295
ELECTRICAL PROPERTIES									
Dielec Str (60 cycles), v/mil	435	496	344	377	393	600	371	400	420
Dielec Const[c]	3.00	2.95	3.80	4.95	4.10	4.80	4.60	3.50	4.10
Dissip Factor[c]	0.8	0.7	1.2	2.8	1.2	2.5	1.2	1.6	1.8
Surface Res (74 F, 86% RH), megohms	4.8×10^5	$>10^8$	$>10^8$	5.08×10^5	5.32×10^5	—	4.46×10^4	2.0×10^3	8.02×10^4

Type ⇒	Sheets[a]					Rods and Tubes[a]			
	GP	El[d]	H Ht	H Ht, Ch	St Fl, H DQ	GP	El	H Ht, Ch	St Fl, H DQ
PHYSICAL PROPERTIES[b]									
Specific Gravity	1.20	1.17	1.43	1.24	1.27	1.21	1.15	1.24	1.27
Water Absorption (24 hr), %	0.06	0.22	0.15	0.12	0.08	0.06	0.12	0.12	0.07
Color	Black	Black	Black	Black	Yellow-brown	Black	Black	Black	Yellow-brown
MECHANICAL PROPERTIES									
Ten Str, 1000 psi	9.3	2.55	7.4	7.17	7.45	9.7	3.6	7.17	6.5
Elong (in 2 in.), %	5.00	33.00	1.20	2.70	5.30	5.00	16.00	2.70	3.80
Hardness (Rockwell)	112–79	—	86–60	115–85	112–80	107–70	—	115–85	112–80
Hardness (durometer)	80–86	50–60	86–92	84–90	80–86	80–86	65–75	84–90	80–86
Impact Str (Izod notched), ft-lb/in.	0.48	0.51	0.53	0.41	0.50	0.48	0.48	0.41	0.52
Flex Str, 1000 psi	16.6	—	9.64	11.3	14.95	11.375	—	11.3	9.06
Heat Dist Temp, F	159	Low	221	275	150	163	Low	275	217
ELECTRICAL PROPERTIES									
Dielec Str (60 cycles), v/mil	487	437	613	400	415	524	512	400	374
Dielec Const[c]	2.95	3.00	3.25	3.50	3.70	2.90	3.15	3.50	3.60
Dissip Factor[c]	0.5	1.3	0.6	1.6	0.6	0.5	1.4	1.6	0.9
Surface Res (74 F, 86% RH), megohms	2.23×10^7	2.66×10^4	$> 10^8$	2.0×10^3	7.98×10^4	$> 10^8$	$> 10^8$	2.0×10^3	6.73×10^4

[a] **GP = general purpose, H = high, HT = heat resistance, Ar = arc resistance, Wr = wear resistance, DQ = dielectric quality, Ch = chemical resistance, MA = low moisture absorption, El = elongation, St = strength, Fl = flow resistance. These designations are** arbitrary abbreviations of principal properties and are not standard.

[b] **Hard rubber in general has a thermal coefficient of linear expansion of 0.00004 per °F.**

[c] **Frequency: 1 kc-1 mc.**

[d] **Semihard.**

Rubber—Molded, Extruded

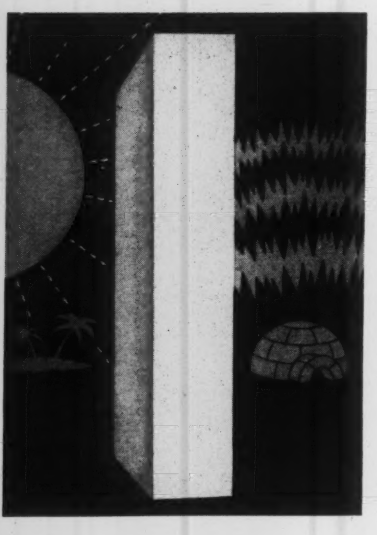
Type ➜	**Natural Rubber**	**Butadiene-Styrene** (GR-S)	**Butadiene-Acrylonitrile** (nitrile)	**Chloroprene** (neoprene)	**Butyl** (isobutylene-isoprene)
PHYSICAL PROPERTIES					
Specific Gravity	0.93	0.94	1.00	1.25	0.90
Ther Cond, Btu/hr/sq ft/°F/ft	0.082	0.143	0.143	0.112	0.053
Coef of Ther Exp (cubical), 10^{-5} per °F	37	37	39	34	32
Electrical Insulation	Good	Good	Poor	Fair	Good
Flame Resistance	Poor	Poor	Poor	Good	Poor
Min Rec Svc Temp. F	-60	-60	0	-40	-50
Max Rec Svc Temp, F	180	180	250	240	300
MECHANICAL PROPERTIES					
Ten Str, psi					
Pure Gum	2500-3500	200-300	500-900	3000-4000	2500-3000
Black	3500-4500	2500-3500	3000-4500	3000-4000	2500-3000
Elongation, %					
Pure Gum	750-850	400-600	450-700	800-900	750-950
Black	550-650	500-600	450-650	500-600	650-850
Hardness (durometer)	A30-A90	A40-A90	A40-A95	A40-A95	A40-A90
Rebound					
Cold	Excellent	Good	Good	Very good	Bad
Hot	Excellent	Good	Good	Very good	Very good
Tear Resistance	Excellent	Fair	Good	Fair to good	Good
Abrasion Resistance	Excellent	Good to excellent	Good	Good	Good to excellent
CHEMICAL RESISTANCE					
Sunlight Aging	Poor	Poor	Poor	Very good	Very good
Oxidation	Good	Good	Good	Excellent	Excellent
Heat Aging	Good	Very good	Excellent	Excellent	Excellent
Solvents					
Aliphatic Hydrocarbons	Poor	Poor	Excellent	Good	Poor
Aromatic Hydrocarbons	Poor	Poor	Good	Fair	Poor
Oxygenated, Alcohols	Good	Good	Poor	Poor	Very good
Oil, Gasoline	Poor	Poor	Excellent	Good	Poor
Animal, Vegetable Oils	Poor to good	Poor to good	Excellent	Good	Excellent
Acids					
Dilute	Fair to good	Fair to good	Good	Excellent	Excellent
Concentrated	Fair to good	Fair to good	Good	Good	Excellent
Permeability to Gases	Fair	Fair	Fair	Low	Very low
Water Swell Resistance	Fair	Excellent	Excellent	Fair	Excellent
USES	Pneumatic tires and tubes; power transmission belts and conveyor belts; gaskets; mountings; hose; chemical tank linings; printing press platens; sound or shock absorption; seals against air, moisture, sound and dirt		Carburetor diaphragms, self-sealing fuel tanks, aircraft hose, gaskets, gasoline and oil hose, cables, machinery mountings, printing rolls	Flexible petroleum tubes and hoses, petroleum and chemical tank linings; electrical insulation in contact with oil, flashlight cases, electrical sockets, special truck tires	Truck and automobile tire inner tubes, airing bags for tire vulcanization and molding, steam hose and diaphragms, flexible electrical insulation

Rubber—Molded, Extruded

Type ➡	**Polysulfide** (Thiokol)	**Silicone** (polysiloxane)	**Urethane** (diisocyanate polyester)	**Fluorinated Acrylic** (dihydroperfluorobutylacrylate)	**Viton** (vinylidene fluoride-hexafluoropropylene)
PHYSICAL PROPERTIES					
Specific Gravity	1.35	1.25	1.25	1.5	—
Ther Cond, Btu/hr/sq ft/°F/ft	—	0.11–0.12	—	—	—
Coef of Ther Exp (cubical), 10^{-5} per °F	—	67	—	—	—
Electrical Insulation	Fair	Excellent	Fair	Good	Excellent
Flame Resistance	Poor	Fair	Good	Good	Good
Min Rec Svc Temp, F	−60	−120	−65	0	−50
Max Rec Svc Temp, F	250	550	240	450	450
MECHANICAL PROPERTIES					
Ten Str, psi					
Pure Gum	>1000	600–1000	>5000	1200	>2000
Black	—	—	—	—	—
Elongation, %					
Pure Gum	450–650	60–400	540–750	300	>350
Black	—	—	—	300	—
Hardness (durometer)	A40–85	A40–85	A35–100	A55	A60–90
Rebound					
Cold	Good	Excellent	Bad	—	Good
Hot	Good	Excellent	Good	—	Excellent
Tear Resistance	Poor	Poor	Good	Poor	Fair
Abrasion Resistance	Poor	Poor	Excellent	Poor	—
CHEMICAL RESISTANCE					
Sunlight Aging	Very good	Excellent	Excellent[a]	Good	Excellent
Oxidation	Very good	Very good	Very good	Good	Excellent
Heat Aging	Fair	Outstanding	Excellent[a]	Good	Outstanding
Solvents					
Aliphatic Hydrocarbons	Excellent	Poor	Excellent	Excellent	Excellent
Aromatic Hydrocarbons	Excellent	Poor	Excellent[b]	Excellent	Excellent
Oxygenated, Alcohols	Very good	Fair	Poor	Good	Poor
Oil, Gasoline	Excellent	Fair	Excellent	Excellent	Excellent
Animal, Vegetable Oils	Excellent	Excellent	Excellent	Excellent	Excellent
Acids					
Dilute	Good	Excellent	Fair	Excellent[c]	Excellent
Concentrated	Good	Fair	Poor	Excellent[d]	Good
Permeability to Gases	Extremely low	Fair	Excellent	Fair	—
Water Swell Resistance	Excellent	Excellent	Excellent	Poor	Excellent
USES	Seals, gaskets, diaphragms, valve seat disks, flexible mountings, hose in contact with solvents, balloons, boats, life vests and rafts	Wire and cable covering, gaskets, tubing, diaphragms, vibration mountings, rollers, insulators, valve seats and closures	Fork lift truck wheels, airplane tail wheels, back-up wheels for turbine blade grinders, spinning cots for glass fiber, hydraulic accumulators, shoe heels	O-rings; V-rings; diaphragms; special applications involving contact with halogenated solvents, organic phosphates and carbon tetrachloride	Critical seals, gaskets, diaphragms, flexible mounts, coated fabrics, etc., for service in chemical and thermal environments

[a] Discolors, but no change in properties.
[b] For up to 80% aromatics.
[c] To diesters, 450 F.
[d] To fire resistant hydraulic fluids, 450 F.

FIVE REASONS WHY
IS THE BEST ANSWER



DYLITE IS AN INSULATOR

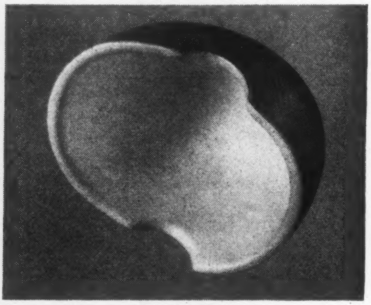
The Thermal Conductivity (K Factor) of DYLITE is 0.242 at a 75°F. mean temperature at 2 lb./cu. ft. density. DYLITE is highly resistant to the passage of heat and is unaffected by moisture condensate. DYLITE is easily molded to fit the contours of component parts of refrigerators, air conditioners and freezer cabinets.

DYLITE IS WATERPROOF

At 2 lb./cu. ft. density, DYLITE's rate of Water Vapor Transmission is 1.18 perms., and its rate of Water Absorption is 0.54 lbs./cu. ft. after 48 hrs. immersion. DYLITE is ideal for boats, rafts, buoys and other types of buoyant marine equipment. DYLITE remains in the water indefinitely without becoming waterlogged, and it is mildew-proof.

DYLITE IS SHOCK-RESISTANT

DYLITE possesses an Energy Absorption ratio (Maximum Load) of 56.74 in. lbs./cu. in. at a density of 2 lb./cu. ft. For example, police safety helmets with shock-absorbent DYLITE liners are now used extensively—a result of performance tests in which DYLITE was proved superior to other materials for this job.



Typical Properties of DYLITE—Density 2 Lb./Cu. Ft.

- Compressive Strength—30 Psi
- Tensile Strength—55 Psi
- Water Vapor Transmission—1.18 Perms.
- Water Absorption—0.54 Lbs./Cu. Ft. After 48 Hrs. Immersion
- Thermal Conductivity (K Factor)—0.242 at a 75°F. Mean Temperature
- Energy Absorption (Maximum Load)—56.74 In. Lbs./Cu. In.

DYLITE is a registered trademark of Koppers Company, Inc.

DYLITE

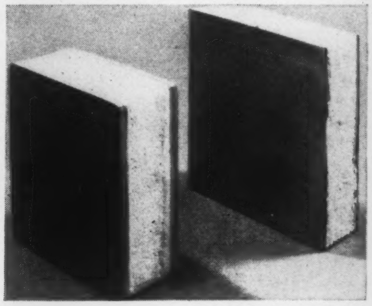
TO YOUR DESIGN PROBLEMS

DYLITE IS LIGHTWEIGHT

DYLITE is lighter than cork—it can be molded in densities of 1 to 10 lb./cu. ft. The advantages of light weight are obvious. In packaging, DYLITE helps reduce shipping costs and makes handling easier. In the construction field, where DYLITE is used as an insulator, its light weight means fast and easy installation.

DYLITE IS STRONG

DYLITE has a Compressive Strength of 30 psi and a Tensile Strength of 55 psi at a 2 lb./cu. ft. density. DYLITE can be used to great advantage in a wide variety of industrial design problems. For instance, sandwich structures that employ DYLITE as the core material offer high strength without sacrificing light weight.



DYLITE

Koppers Company, Inc.
Plastics Division
Dept. MDE-109
Pittsburgh 19, Pennsylvania

☐ Please send me more information on DYLITE expandable polystyrene.

☐ Please have Koppers representative call.

☐ I'd like more information on DYLITE concerning possible application in__________

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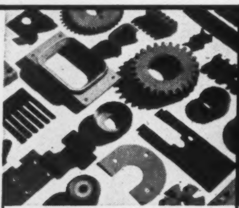
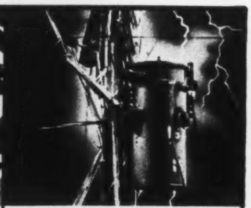
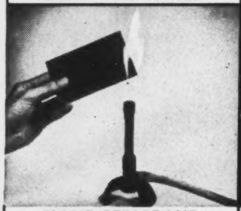
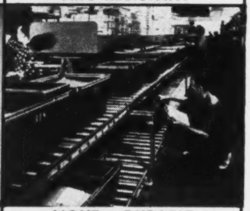
- Good Dielectric Strength
- Impact Resistant
- Arc Resistant
- Heat Resistant
- Track Resistant
- Durable
- Machinable

Among engineering materials Vulcanized Fibre is outstanding in its application versatility. One of industry's toughest materials, it weighs less than half as much as aluminum. It is easily formed, deep drawn, machined, polished, painted, embossed, or combined with other materials.


EASILY FABRICATED


ARC RESISTANT


FLAME RETARDANT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DELRIN®
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- Strength
- Stiffness
- Toughness
- Low static friction
- Solvent resistant
- Abrasion resistant

PENTON®
(Hercules Powder Co.—chlorinated polyether)
- Strong
- Stable
- Moisture resistant
- High heat distortion
- Resistant to corrosive chemicals

PHENOLITE® Laminated PLASTIC

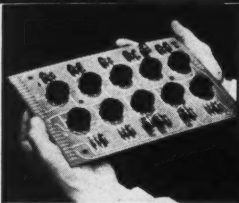
- Dielectric Strength
- Structural Strength
- Dimensional Stability
- Machinability
- Heat Resistance
- Moisture Resistance
- Chemical Resistance
- Wear Resistance
- Flame Resistance

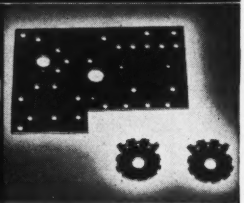
A plastic laminated into primary forms—sheets, rods, tubes under heat and high pressure.

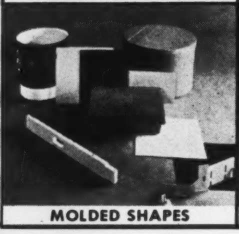
A wide variety of base materials—paper, canvas, cotton fabric, asbestos, glass cloth, glass mat, and nylon cloth—are impregnated with resin binders—phenolic, silicone, polyester, melamine, and epoxy—providing a broad range of grades with an unlimited application base.

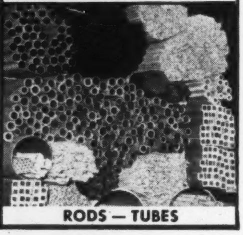
Available as copper clad and in combination with vulcanized fibre, rubber and other materials.

Molded Polyester Shapes


COPPER CLAD


FABRICATED PARTS


MOLDED SHAPES


RODS — TUBES

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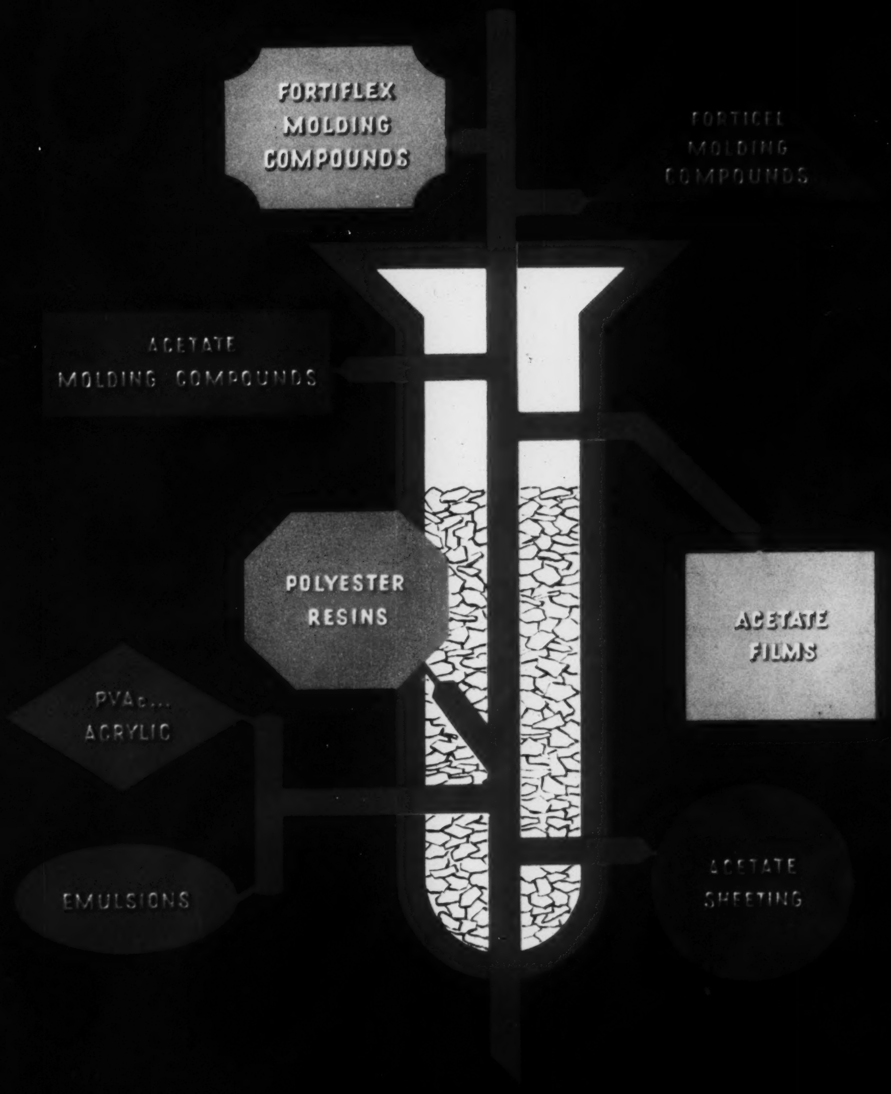

FORTIFLEX MOLDING COMPOUNDS
FORTICEL MOLDING COMPOUNDS
ACETATE MOLDING COMPOUNDS
POLYESTER RESINS
ACETATE FILMS
PVAc... ACRYLIC
EMULSIONS
ACETATE SHEETING

Celanese

PLASTICS

FORTIFLEX . . . A high-density

Fortiflex A is a series of linear polyolefins, produced by a low-temperature, low-pressure method. The high crystallinity of Fortiflex A (93% compared to 65% for conventional polyethylene) results in superior physical properties. Fortiflex A is a rigid, tough, heat-resistant thermoplastic. Molded parts can be sterilized at temperatures up to 250°F. Fortiflex A can be molded with relative ease into parts having a lustrous finish and good chemical resistance. The material has extremely low permeability to liquids and gases, and its tensile properties are excellent.

Fortiflex A is available in both natural and colored molding powders. Five formulations provide a wide flow range:

FORTIFLEX A-20 possesses the highest impact strength, stress cracking resistance and low-temperature strength of the series. It requires somewhat higher process temperatures. Recommended for extrusion, calendering, blow molding, or injection molding of very small parts requiring maximum physical properties.

FORTIFLEX A-70 is a general-purpose resin. Recommended for i jection molding of small parts with limited surface area. Th resin is also suggested for extrusion, calendering, blow moldi and as a rubber compounding additive.

FORTIFLEX A-250 is used for intermediate-sized injection mold articles where better moldability and improved surface finish a required. Also suited for the extrusion of film.

FORTIFLEX A-500 possesses the best moldability for large-ar moldings and applications where maximum processability is quired.

FORTIFLEX A-800 is designed primarily for use as a blending co ponent with conventional polyethylene. It offers substantially i proved flow characteristics and has reduced impact strength compared to other resins in the Fortiflex A series. It is suggeste for use in blends, single-use containers, or items requiring l

PHYSICAL PROPERTIES RELATED TO MELT INDEX

Property	Units	ASTM Method	A-20	A-70	A-250	A-500	A-800	B50-20	B50-80 to B50-500
Melt Index	—	D1238-52T	0.2	0.7	2.5	5.0	8.0	0.2	0.8-5.0
Heat Distortion Temp., 66 psi.	°F.	D648-56	185	185	180	180	180	170-175	170-175
Impact Strength(1), Notched Izod(2)	ft. lb./ in. notch	D256-54T	23	18	13	3	0.7	7	5-1
Tensile Strength, 0.2 in./min.(3)	psi.	D638-52T	3700	3600	3500	3300	3300	3200	3100
Elongation, 0.2 in./min.(3)	%	D638-52T	28	25	18	13	13	30	25-18
Environmental Stress Cracking Resistance, F_{50} Value	hr.	Bell Lab.(4)	190	30	6	3	—	2000	(5)

PHYSICAL PROPERTIES NOT RELATED TO MELT INDEX

Property	Unit	ASTM Method	Fortiflex A	Fortiflex B50
Density	g/cc.	D792-50	0.96	0.95
Highest Use Temperature(6)				
Continuous	°F.	—	180	—
Intermittent	°F.	—	225	—
Softening Temperature(7)	°F.	—	260	255
Stiffness in Flexure	psi	D747-50	140000	100000
Hardness	Rockwell R	D785-51	40	40
	Shore D	D676-49	65	64
Mold Shrinkage(8)				
Length	in./in.	—	0.010-0.030	0.010-0.030
Width	in./in.	—	0.010-0.025	0.010-0.025
Flammability	in./min.	D635-44	1.0	1.0
Water Absorption, 24 hr. at 77°F.	% gain	D570-54T	< 0.01	< 0.01
Refractive Index	n_D25	D542-50	1.54	1.54

TYPICAL ELECTRICAL PROPERTIES OF FORTIFLEX A AND FORTIFLEX B-50

Property	Units	ASTM Method	Frequency (cycles per sec.)	Value
Dielectric Strength (short time)	volts/mil	D149-55T	—	500
Volume Resistivity	ohm cm.	D257-54T	—	6×10^{15}
Dielectric Constant	—	D150-54T	1×10^3	2.35
			1×10^6	2.36
Dissipation Factor	—	D150-54T	1×10^3	0.0002
			1×10^6	0.0003
Loss Factor	—	D150-54T	1×10^3	0.0007
			1×10^6	0.0007

GAS PERMEABILITY OF FORTIFLEX A

Gas	Units	Value*
Carbon Dioxide	(cc. cm./sec. cm.^{2} cm. Hg.) x 10^{-9}	0.21
Hydrogen		0.20
Oxygen		0.07
Helium		0.15
Ethane		0.15
Natural Gas (ca. 99% Methane)		0.07
Freon		0.06

*Determined on 2 mil blown tubing by method of Baubaker and Kammermeyer, Ind. Eng. Chem. 45, 1148 (1953).

CHEMICAL RESISTANCE OF FORTIFLEX A

Chemical	Value*
ACIDS	
Acetic Acid, glacial	0.7
Oleic Acid	0.7
Sulfuric Acid 98%	0.0
Nitric Acid 70%	0.3
BASES	
Sodium Hydroxide 50%	0.0
Ammonium Hydroxide 28%	0.0
SOLVENTS	
Acetone	0.7
Carbon Tetrachloride	14.0
Ethanol	0.1
Ethyl Acetate	2.3
Methyl "Carbitol"	0.1
MISCELLANEOUS	
Water	0.0
Gasoline	6.0
Lubricating Oil	0.6
Brake Fluid	0.2

*% Increase in wt. after 30 days immersion at 80°F. Sample specimens were 1''x¼''x⅛'' 0.035.

FOOTNOTES

(1) Impact values observed on injection molded bars should not be consic ered indicative of practical impact values for molded items where othe factors affect the impact value. While its impact value will be sufficien for most uses, Fortiflex B should be evaluated for each specific appli cation.

(2) Injection molded specimens, ⅛''x½'' cross section, notch in the ⅛ face. A-20, A-70 and A-250 specimens did not break. A-500 and Fortifle B50 copolymers exhibited partial or hinged breaks.

(3) Injection molded Type I specimens, ⅛'' thick. Tensile strength and elon gation data recorded at the first yield point.

(4) ASTM Standard on Plastics, Issue of February, 1957. Appendix, page 83 – Proposed Method of Test for Environmental Stress Cracking of Ethylen Plastics.

(5) Fortiflex B50-80 has an environmental stress cracking resistance F_{50} valu of 160 hrs.

(6) Highest use temperature depends on part design, molding and servic conditions, special formulations are available for continuous use a higher temperatures up to 212°F

(7) Method of Karrer et al, Ind. Engr. Chem., Anal. Ed. 2, 96 (1930).

(8) Mold shrinkage depends on part design and molding conditions.

inear polyolefins

ipact strength such as certain toys and novelties. Not recomended where stress cracking is a problem.

AME RESISTANT FORTIFLEX. In order to meet the increasing mand for flame resistant materials, Celanese is offering speally formulated variations of Fortiflex A-70, A-250 and A-500. iese flame resistant Fortiflex formulations are opaque, selftinguishing high-density polyethylenes with a specific gravity 1.04. Their stiffness, hardness and tensile strength are approxiately the same as the standard resins'. However, heat distortion lues under 66 psi are slightly lower and impact strength is mewhat reduced. Burning rate or flammability is reduced to e point where they can be classified as non-burning materials ider ASTM D-635-44.

Applications for Fortiflex A include: housewares and applices, electrical and automotive parts, filaments for textiles and pe, packaging materials, bottles and containers, toys, industrial irts and protective helmets.

ORTIFLEX B

rtiflex B, a group of linear copolymers, is the latest in the Fortiflex family. It was veloped to provide special advantages. With the addition of Fortiflex B, the Fortix series provides a family of resins with an extremely broad range of properties iich make it possible to upgrade many applications now employing other thermoastics while it also opens up many new fields of application for plastics.

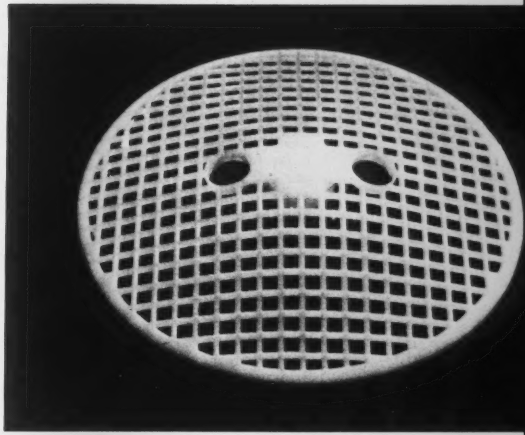
Fortiflex B is an excellent injection molding plastic and provides outstanding ess crack resistance. Processability of Fortiflex B resins is somewhat improved er the Fortiflex A series resins when compared with them on a melt index for melt lex basis. Thus, cycle time for a given part is somewhat less for these resins as mpared to Fortiflex A, since their cold point and viscosity are lower. The improved w properties result in faster fill and freeze times.

In tests under a static load, properly oriented filaments of the new polymer show duced tendency to stretch. Under sustained stress they resist failure up to ten times iger than previous polyolefin filaments.

The Fortiflex B series is recommended for end-uses such as filaments for rope and tdoor furniture webbing, wire covering, blown bottles and containers, paper coatg, film, and pipe.

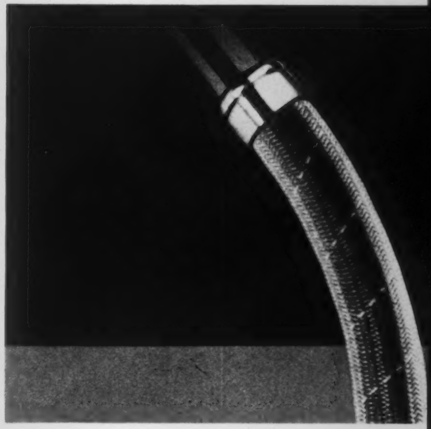
Possible applications for injection molding are: containers for stress-active ents, drum plugs, fittings and couplings, thin-walled moldings, large area moldgs, insert moldings, bottle caps and closures.

New prospects for the blow molding of bottles and hollow-ware have been opened molders by the Fortiflex B series.



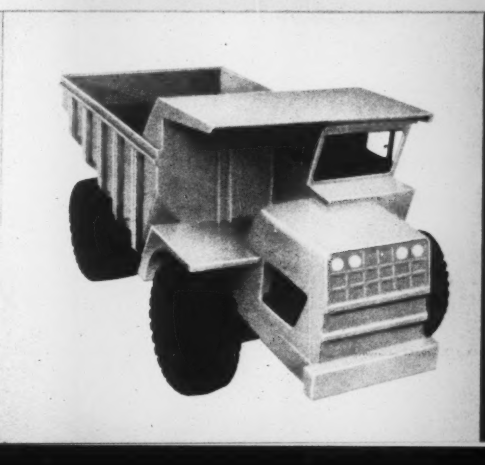
LINT SCREEN for gas and electric dryers has rigidity, toughness, heat resistance. Smooth, lustrous surface of Fortiflex handles laundry gently.

VACUUM-CLEANER HOSE armored with Fortiflex filament is strong, light in weight, abrasion resistant. Filament has high tenacity, low elongation.



LORFUL HOUSEWARES molded of Fortiflex e lustrous surface and high impact strength. y are rigid, tough, light in weight . . . hstand boiling heat and freezing cold.

MASSIVE, HEAVY-DUTY DUMP TRUCK molded of Fortiflex has high strength and rigidity. Large toy moldings and weight-bearing toys are made possible by Fortiflex.



G. E. VAPORIZER uses unbreakable, lightweight bottle which holds nearly a gallon of water. Fortiflex is an outstanding material for blow molding hollow shapes.

FORTICEL cellulose propionate

Forticel is distinctive among thermoplastics for its excellent *balance* of desirable properties. Its combination of toughness and good flexural strength is unique among cellulose ester plastics. Moreover, the high impact strengths of Forticel occur at moderate plasticizer levels, where its other good characteristics, such as dimensional stability and stiffness, are also optimum. No other cellulose plastic of similar general properties has less humidity expansion. The low water absorption of Forticel results in stability against warpage. Forticel has considerably more resistance to weathering than cellulose acetate and is very similar to cellulose acetate butyrate in this respect.

Forticel is exceptional for the luster of its molded surface, which is obtainable on a fast cycle—in some items the fastest of all the cellulosics. A free flowing plastic, it can be injection molded with great ease and lends itself to restricted gating and complicated mold layouts. Its superior flow insures practically invisible weld lines where two streams of plastic meet in the die. Forticel eliminates problems of flow around mold pins. Finished parts of Forticel are free from objectionable odor, so that Forticel is often used for personal items such as mascara brushes and containers, toothbrushes, toys, and telephone headsets.

Forticel is produced in four series of formulas offering different flow ranges and end-use advantages. Forticel is available in a range of transparent, translucent and opaque colors. Applications include: pens, telephone housings, automotive parts, optical frames, business machine keys, vacuum cleaner attachments, handles, small equipment housings.

CHEMICAL RESISTANCE*

Reagent	Effect
ACIDS	
30% Sulfuric	No change
30% Sulfuric	No change
10% Nitric	Surface attacked
5% Acetic	No change
10% Hydrochloric	No change
Oleic	No change
BASES	
10% Sodium Hydroxide	Sl. surface attack
1% Sodium Hydroxide	No change
10% Ammonium Hydroxide	Sl. surface attack
2% Sodium Carbonate	No change
ORGANIC SOLVENTS	
Carbon Tetrachloride	Swollen
Gasoline (white)	No change
AQUEOUS SOLUTIONS	
Water	No change
10% Sodium Chloride	No change
3% Hydrogen Peroxide	No change

*ASTM method D-543

ELECTRICAL PROPERTIES*

Dielectric Constant at 10^6 cycles	D-150-54T	3.0 to 3.5
Power Factor at 10^3 cycles	"	0.010 to 0.011
Power Factor at 10^6 cycles	"	0.017 to 0.020
Insulation Resistance (megohms)	D-257-54T	2×10^6
Dielectric Strength (volts/mil)	D-149-55T	800 to 1,500

*Measured at 73°F. and 50% R.H.

The electrical properties of Forticel are considerably more constant over a humidity range than those of cellulose acetate because of much lower water absorption.

TYPICAL PHYSICAL PROPERTIES OF FORTICEL

		Flow Temperature	Specific Gravity	Rockwell Hardness	Impact Strength (Izod)	Heat Distortion Temp.	Tensile Strength	Elongation	Flexural Strength	Water Absorption	Molding Cold Poin
	Unit	°C		R Scale	ft. lb./in. notch	°C	psi	%	psi	%	°F
	A.S.T.M. Test	D569-48	D792-50	D785-51	D256-54T	D648-45T (264 psi)	D638-52T	D638-52T	D790-49T	D570-54T	Relativ
JM SERIES	A-(H2)	179	1.24	106	1.2	70	5,900	63	10,000	2.00	425
	B-(H2)	176	1.23	102	1.4	67	5,400	60	9,400	1.90	415
	A-(H)	174	1.22	97	1.6	65	4,900	55	8,900	1.80	405
	B-(H)	171	1.22	89	2.4	63	4,600	55	8,500	1.80	390
	A-(MH)	168	1.21	82	4.2	61	4,300	54	7,800	1.70	380
	B-(M)	165	1.20	70	8.5	59	3,900	54	6,600	1.70	360
	A-(MS)	162	1.20	62	10.5	57	3,500	54	6,200	1.70	340
	B-(MS)	159	1.19	53	10.8	56	3,300	53	5,800	1.70	325
	A-(S)	156	1.19	43	11	55	2,900	52	5,200	1.60	310
	B-(S)	153	1.19	33	11	53	2,600	51	4,500	1.60	295
	A-(S2)	150	1.19	21	11	52	2,400	50	4,000	1.60	280
	A-(S3)	145	1.18	–15	10	51	1,900	48	3,000	1.60	260
JL SERIES	A-(H2)	183	1.24	100	1.7	70	5,400	50	10,000	2.00	420
	B-(H2)	178	1.23	95	2.0	69	5,000	56	9,600	1.80	405
	A-(H)	176	1.21	90	2.4	67	4,800	58	9,200	1.70	390

TELEPHONES IN COLORS add a bright touch to decor. Forticel provides shatterproof toughness, good dimensional stability, high surface luster.

WESTCLOX "TRAVALARM" comes in lustrous ivory or black. Forticel was selected for its toughness, excellent moldability, freedom from unpleasant odor.

FAMOUS NAMES in pens prefer strong Celane Forticel for molding bodies and caps to precis stable dimensions. An example is the Scrip ball point pen.

NEW DESIGN
Scripto
BALL PEN
$1.00

ACETATE molding compounds

cetate is a very widely used cellulosic plastic. Economical and versatile, usefulness extends over a wide range of consumer products.

In toughness, acetate can seldom be matched by any other plastic in price bracket. It has high impact strength, rigidity, a hard surface, tisfactory dimensional stability for many applications. Acetate is free objectionable odor, has practically no taste, and has relatively good mperature stability, which permits its use in refrigerators. The XK ries is formulated entirely of ingredients considered acceptable for use contact with foods by the Food & Drug Administration. Dielectric operties are good. The plastic is unharmed by common hydrocarbons ch as gasoline, benzene and oils.

Acetate has excellent moldability, and molding temperatures are not itical. The plastic is free-flowing, which minimizes the problem of weld nes, and is recommended for applications incorporating metal inserts. cetate molds with an excellent surface finish. With the aid of pre-lasticizing machines, heavy parts can be molded in one cavity and family olds can also be used. Acetate is easily fabricated. Parts may be cemented gether to give a bond as strong as the original pieces. Formulations can e widely varied in properties by use of various types and amounts of lasticizers.

Acetate is produced in a number of formulations—including flame re-stant material in a broad range of flows. It is offered in a practically mitless range of transparent, translucent and opaque colors as well as ystal clear. Applications include: toys, shoe heels, appliance housings, ilet seats, jewelry, tool handles, sun glasses, brush backs.

ELECTRICAL PROPERTIES

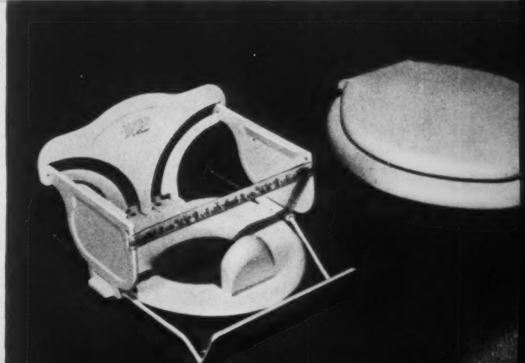
	ASTM Method	Units	Typical Formula XM-H3	Typical Formula XFA-H3
DIELECTRIC STRENGTH	D-149-55T			
0% R.H., 25°C.		volts/mil	390	370
50% R.H., 25°C.		volts/mil	350	360
95% R.H., 25°C.		volts/mil	320	340
VOLUME RESISTIVITY	D-257-54T			
0% R.H., 25°C.		ohm-cm.	10^{14}	10^{14}
50% R.H., 25°C.		ohm-cm.	10^{13}	10^{13}
95% R.H., 25°C.		ohm-cm.	10^{11}	10^{11}
DIELECTRIC CONSTANT	D-150-54T			
1 kilocycle, at				
0% R.H., 25°C.			4.4	4.4
50% R.H., 25°C.			5.2	5.1
95% R.H., 25°C.			7.5	7.9
1 megacycle, at				
0% R.H., 25°C.			3.8	3.8
50% R.H., 25°C.			4.5	4.3
95% R.H., 25°C.			6.5	6.5
POWER FACTOR	D-150-54T			
1 kilocycle, at				
0% R.H., 25°C.			.020	.024
50% R.H., 25°C.			.024	.024
95% R.H., 25°C.			.042	.032
1 megacycle, at				
0% R.H., 25°C.			.038	.041
50% R.H., 25°C.			.048	.055
95% R.H., 25°C.			.050	.055
Arc RESISTANCE	D-495-48T			
50% R.H., 25°C.			175	61

ACETATE FORMULA SERIES

Property	Units	ASTM Method	XM SERIES Range S3	— H7	XL SERIES Range S5	— H4	XR SERIES Range S2	— H2	XP SERIES Range S	— H2	XK SERIES Range MS	— H4	XFB SERIES Range S	— H4
Flow Temperature	°C	D-569-48	125	185	115	170	130	160	135	160	140	170	135	170
	°F		257	365	239	338	266	320	275	320	284	338	275	338
Specific Gravity		D-792-50	1.27	1.30	1.28	1.31	1.27	1.30	1.28	1.28	1.26	1.28	1.25	1.28
Rockwell Hardness	R Scale	D-785-51	40	119	57	120	55	96	50	87	59	108	66	112
Impact Strength (Izod)	ft. lb. / in. notch	D-256-56	5.6	1.2	5.8	1.9	5.0	2.8	5.0	3.2	4.1	2.9	4.2	2.4
Heat Distortion Temp.	°C.	D-648-56	46	74	44	73	50	65	48	61	52	61	50	58
	°F		115	165	111	163	122	149	118	142	126	142	122	136
Deformation Under Load	% change in height —24 hours	D-621-51	37.0	3.0	32.2	4.0	30	13	33	15	6.7	0.2	3.8	1.2
Tensile Strength	psi	D-638-56T	2800	6400	3600	7400	3900	5800	2800	4800	2800	6100	2700	5800
Elongation	%	D-638-56T	52	16	47	16	45	30	50	30	45	33	—	—
Flexural Strength	psi	D-790-49T	2300	11200	4700	11600	4800	8900	2500	7100	5000	10000	6200	11100
Compressive Strength	psi	D-695-54	12000	29000	13800	32500	16200	25700	14000	22500	—	—	14500	27100
Water Absorption	% wt. gain + soluble matter lost	D-570-54T	2.7	2.7	2.1	2.6	2.4	2.6	2.4	2.4	2.3	2.4	4.5	2.8
Weight Loss on Heating	% at 82°C. for 72 hours	D-706-55T	10.8	0.5	8.1	0.7	8.1	3.5	6.0	4.0	6.0	1.2	3.1	0.8

HOE HEELS molded of Celanese Acetate are ugh. They take prolonged pavement pound-ng, resist breakage, can be nailed without plitting.

TOYS, like this famous doll, can be economically molded of acetate . . . are strong, attractive, colorful, light in weight—a pleasure for children to handle.



TOILET SEATS molded of Celanese Acetate are both sturdy and sanitary. They can be molded in colors to match bathroom decor, are easy to keep clean.

POLYESTER RESINS

Celanese polyester resins are thermosetting liquids which are cured in the presence of peroxide catalysts to stable, infusible solids. Cure can be achieved at low temperatures and pressures down to atmospheric pressure. Tack-free cures can be made at ordinary room temperatures through the use of suitable accelerators.

Celanese polyesters are supplied in viscosities ranging from close to that of water to that of heavy molasses. Generally they are clear liquids, except for the thixotropic formulations. They are 100% reactive and are not dependent on the release of solvent or any volatile reaction product for solidification. When reinforced with fibrous glass cloth, laminates can be produced which often have a better strength-to-weight ratio than steel. The cured resins exhibit excellent resistance to moisture, heat, weathering and most chemicals. Electrical properties are outstanding.

These resins are available in a number of formulations wh
can be blended to obtain specific properties in the finished pr
uct. A full range of thixotropic resins is available for use in ha
lay-up on vertical or sloping surfaces where resistance to re
drainage is required. Special sprayable thixotropic resins for u
in spray layup equipment, such as the Rand gun or the Hupp gu
are available. A broad line of fast-cycle press molding resins usi
either styrene, vinyl toluene, or diallyl phthalate monomer is ava
able to cover virtually any requirement for premix, preform,
mat molding. Celanese polyester resins make possible the mo
ing of large and intricate parts by modern fast cycle metho
Applications include: boats, car and truck bodies, corrugated a
flat sheeting, machine housings, auto body fillers, tanks and ta
linings, swimming pools, ornamental laminates and castings, co
ings, electronic parts, and automotive and appliance componen

PHYSICAL AND CHEMICAL PROPERTIES

Laminates Reinforced with 12 plies #181-136 Glass Cloth, According to MIL-R-7575 (USAF) Specifications

Properties at Standard Conditions	Gen. Purpose MR-28C	Gen. Purpose MR-28R	Pre-mix MR-40R	Match die MR-42R
Flexural, Flatwise, Ultimate Strength, psi	61,300	67,400	52,000	75,000
Flexural Tangent Proportional Limit, psi	51,600	32,500	—	—
Flexural Initial Modulus of Elasticity, psi	$2.83\text{x}10^6$	$2.72\text{x}10^6$	$2.8\text{x}10^6$	$3.2\text{x}10^6$
Ultimate Tensile Strength, psi	47,000	47,100	37,000	50,000
Ultimate Compressive Strength Edgewise, psi	37,300	37,900	—	—
Water Absorption, 24 hours, percent weight change	+0.1	+0.05	+0.6	+0.2
Rockwell M. Hardness	103	114.2	110	—
Barcol Hardness	67.5	67.0	63	70
Barcol Hardness of Unfilled Casting (25° C)	50-55	50-53	47	50
Specific Gravity	1.88	1.84	1.08	1.15
Resin Content Percent	35.3	37.0	70	70
Viscosity (25° C), Brookfield Viscometer, cp	650	7,000-10,000	2,000-2,500	2,000-2,500

POLYVINYL ACETATE EMULSIONS

Celanese PVAc resin emulsions are milk-white liquids containing 50-55% polymer solids with viscosities ranging from water-thin to extremely viscous. Use of these emulsions eliminates the need for expensive, flammable, odorous, or toxic solvents, since they are water-based. These emulsions offer the advantage of high solids content with good fluidity and have excellent freeze-thaw, mechanical and storage stability. Celanese PVAc emulsions are presently being used in water-based paints, textile finishes, paper coatings, and adhesives. The latest material is a new vinyl-acrylic emulsion CL-203.

PAINTS. Vinyl paints made with Celanese CL-102 homopolymer and CL-202 copolymer PVAc emulsions offer quick drying, low cost, excellent alkali resistance, and good weathering properties. The paints have practically no odor, spread easily, and provide excellent coverage with uniform color and sheen. Celanese PVAc emulsions have set new standards for film clarity and resistance to water spotting. The films also resist sunlight, oils, solvents, greases. The fine particle size of the paint emulsions insures superior pigment binding, eliminates problems of settling in the can, produces tighter, tougher, more closely-knit films.

Applications: Interior flat paints, exterior masonry paints, primers, semi-gloss paints, and industrial metal finishes. Celanese has developed high-gloss formulations and exterior formulations that adhere excellently to chalky surfaces.

TEXTILE FINISHES. Celanese PVAc finishes improve stiffness, durability, strength and wrinkle recovery of woven fabrics. The emulsions can be used in many textile sizing formulations. They are particularly suited for cotton and acetate fabrics, from lightest to heaviest weaves.

PAPER COATINGS. Scuff-proof paper coatings can often impro
surface durability by a factor of five. In addition to scuff-proofnes
Celanese PVAc finishes upgrade lower-quality papers and for
a good base for color coats. They eliminate fire hazards of fla
mable solvents.

ADHESIVES. PVAc emulsions can be used to make outstandi
adhesives for bonding porous materials such as paper and car
board. The films provide high bond strength, and since the emu
sions are water-based, machinery can easily be cleaned. PVA
adhesives are also used for transparent plastic packaging film
acoustic insulation, wood, tile. They are excellent for packagin

TYPICAL PROPERTIES OF CELANESE POLYVINYL ACETATE EMULSIONS AND FILMS

Properties of Emulsions	CL-100	CL-101	CL-102	CL-202	CL-203
Solids content, %	55±1	55 (Min.)	55±1	55±1	55±1
pH	4-5	4-5	4-5	4-5	4-5
Viscosity, cp.	1000-1500	800-1200	1000-1500	1900-2500	1900-2500
Particle size	medium	large	small	small	medium
Free monomer, maximum %	0.5	0.5	0.5	0.5	0.5
Weight per gallon, lb.	9.2	9.2	9.2	9.1	9.1
Odor	very slight	very slight	very slight	very slight	slight
Borax stability	poor	poor	excellent	excellent	excellent
Settling after dilution					
After 4 days, ml.	4	5	2	1	1
After 13 days, ml.	6	8	3	1	1
Properties of Films					
Clarity and gloss	good	fair	excellent	excellent	excellent
Water spotting	moderate	severe	slight	slight	slight

;ELLULOSE ACETATE FILM

lanese Acetate film is an economical thermoplastic material lely used for its sparkling clarity and ease of processing. Acee is readily slit, cut, laminated, metallized and printed. High ·ed and automatic operations may be employed. The plastic 1 be sealed rapidly with heat and solvents, has a long shelf life, l does not block under most conditions of storage. Available thicknesses from 0.0005" to 0.002", these materials are offered a broad range of widths, continuous lengths, and cut sheets clear transparent.

Celanese Acetate film is manufactured in two types: cast and ruded. These are generally similar in appearance and proper-;, and can be used interchangeably in many applications. The t type is a premium quality film outstanding for its perfection surface, grainless transparency and uniformity. Both film types produced in a number of formulations to fit specific applicans. The excellent physical and mechanical properties of Celae Acetate films provide many important advantages, such as:

:ellent transparency. Celanese Acetate is crystal-clear and inless. In packaging it gives product visibility at all times.

ıg shelf life. Celanese Acetate retains its original strength over g periods of time, because there is no highly volatile substance evaporate and make the material brittle. It does not block in rage.

nensional stability. Celanese Acetate resists dimensional change n under widely varying atmospheric conditions. This means t overwrapping produces a neat, trim package.

Mold retardance. Celanese Acetate is extremely resistant to the growth of mold, germs, fungi, and other infestations.

Resistance to fogging. Celanese Acetate resists fogging in humid, cold cabinets and will gradually dissipate fog upon rapid changes in temperature and humidity.

High permeability to gases. Celanese Acetate is the most desirable film where good transparency and gas or vapor transmission are required to eliminate high gaseous concentrations. To achieve this effect with most other films, perforation is necessary.

Excellent greaseproofness. Celanese Acetate is highly resistant to most greases.

Printability. Celanese Acetate provides an excellent surface for clear, sharp printed impressions. When printed in reverse it gives added depth, lustre and brilliance to printed impressions.

Ease of fabrication. Celanese Acetate is readily slit, cut, laminated, metallized and printed by simple or high speed automatic operations. It heat seals and solvent seals rapidly.

Applications for Celanese Acetate film include: metallizing, electrical insulation of many types, backing for magnetic recording tape, pressure-sensitive tape, gold stamping foil and decorative ribbons. It is also used in pouches, envelopes and protective covers of all types; multiple layer, three-dimensional illustrations of industrial equipment; over-wraps for packaging of long shelf-life merchandise, as well as fresh produce and bakery products.

TYPICAL PROPERTIES OF ACETATE FILMS*

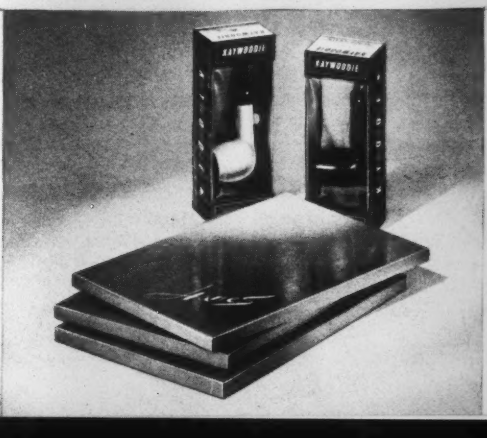
Formula	P 903	P 904	P 907	P 911	P 912	S 600	S 650	S 602	S 652
Thickness Range, inches	0.00088	0.00088	0.0007	0.00088	0.0007	0.0005	0.0005	0.0005	0.0005
	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Specific Gravity	1.26	1.31	1.32	1.31	1.30	1.31		1.29	
Tensile Strength, psi	7000-9000	9000-12000	12000-13000	7800-8500	8000-12000	7000-10000	7000-10000	7000-9000	7000-9000
Elongation, %	25 - 35	15 - 25	31 - 42	15 - 25	20 - 30	25 - 50	25 - 50	30 - 55	30 - 55
Softening Temperatures**									
°C.	125	175	150	125	150	150	150	140	140
°F.	260	350	300	260	300	300	300	285	285
Heat Shrinkage, %									
48 hr., 60°C. (140°F.)	1.5-2.5	0.05 0.2	0.1-0.3	1.0-2.0	1.0-2.0	0.1-1.0	0.1-1.0	0.2-1.5	0.2-1.5
48 hr., 116°C. (240°F.)	4.0-6.0	0.9-1.5	1.9-2.6	5.0-7.0	3.5-4.5	2.0-4.0	2.0-4.0	3.0-5.0	3.0-5.0
Moisture Absorption, %									
24 hr., 0% RH. plus									
48 hr., 90% RH.	4.0	8.5	5.4	3.5	4.5	4.5	4.5	3.5	3.5

*All tests were made after the samples had been conditioned for 24 hours at 50% relative humidity and 25°C. (77°F.), and the tests were made under the same conditions.

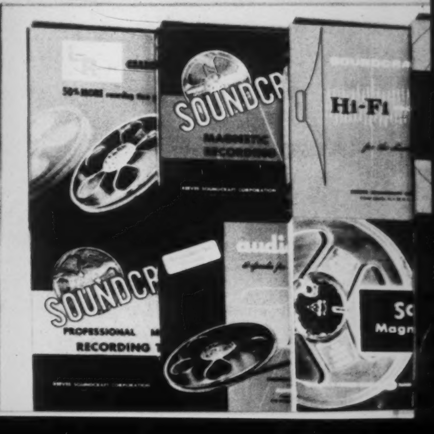
**Softening Temperature—Temperature at which sample becomes limp when heated on a polished copper block at rate of 15°C. per minute. Samples conditioned before testing for at least 24 hours at 50% RH. and 23°C.

CE SHIELD of Celanese Acetate sheeting dem-:trates the clarity and sparkle of the mate-l—and its use as a strong, protective window.

SEE-AND-SELL PACKAGES come in hundreds of shapes, sizes and forms. All sorts of products enjoy a personal showcase on the buying world through Celanese Acetate.



ACETATE BASE RECORDING TAPES eliminate background noise, permit faithful reproduction. They resist stretching even under strong rewind tension.



CELLULOSE ACETATE SHEETIN

Celanese Acetate sheeting is a thermoplastic material produced by solvent casting and dry extrusion. The excellent physical and mechanical properties of this sheeting provide many important advantages for a wide range of application These include:

Ease of fabrication. Celanse sheeting can be easily die cut, beaded, punched, stitched, embossed, laminated and cemented.

Excellent thermoforming. Celanese sheeting can be formed by all conventional thermoforming methods. The most popular is vacuum forming.

Toughness. Celanese sheeting has good impact resistance over a range of temperatures. It does not craze or crack under normal stresses.

Rigidity. Celanese sheeting does not become limp or distort under normal high temperature.

Good aging properties. Celanese sheeting does not discolor with age nor become brittle over long periods of time.

Excellent printability. Celanese sheeting can be printed by gravure, letterpress, flexography or silk screen. The excellent surface provides clean, sharp impressions. The sparkling clarity of clear, transparent sheeting provides a lustrous surface to complement quality printing.

Grease resistance. Celanese acetate is excellent for the containment of greases and oils. Approved under MIL-T-21484 for blister packages for bearings.

Colorability. In addition to the clear transparent product, Celanese sheeting is available in a wide range of colors, both transparent and opaque.

CAST SHEETING. Cast sheeting is produced in several forn tions in continuous length rolls, gauges 0.003" through 0.(It is manufactured in clear transparent only, but can be sur tinted with transparent colors. Cast sheeting has a grainless face of high perfection and is recommended for application quiring the best optical clarity and greatest rigidity. For sp applications cast sheeting can be supplied with a contin matte surface. Although produced in continuous lengths, sheeting can also be supplied in stock size or cut-to-size sh

EXTRUDED SHEETING. Extruded sheeting is produced in a range of formulations. It is available in continuous length r gauges 0.003" through 0.030". It is also produce din sheets 0.(through 0.250". The wide range of formulations assures pr selection of a suitable material for a specific application. Cer formulations are compounded entirely of ingredients accept to the Food and Drug Administration in connection with packaging.

Extruded sheeting is manufactured in clear transparent an an unlimited range of transparent to opaque colors. This shee is economically priced and can also be supplied in a variet finishes. The most common finishes are "as extruded," high pol and matte.

Applications for Celanese Acetate sheeting include: Trans ent containers and proective covers. Contour, blister and s type packages. Personal accessories such as costume jewe buttons, handbags. Optical frames, face shields, safety gogg and safety devices. Transparent sheets for printing. Loose- insert folders. Toys and games.

PROPERTIES OF ACETATE SHEETING

Property	Test Method	Units	CAST SHEET				EXTRUDED SHEET				
			.003" Gauge		.010" Gauge		0.010" Gauge				
			L-822	L-864	L-822	L-864	S-700	S-704	S-712	S-729	S-732
Tensile Strength	D882-56-T Method B	psi	12,000	11,500	11,000	10,500	7200	7500	7500	7900	8000
Elongation	Method B	%	38.	40.	41.	45.	68	70	73	67	71
Mullen Burst Strength	—	psi	100	100	300	300	210	210	200	230	230
MIT Fold Endurance	D643-43 Method B	No. of double folds	100	100	10	10	16	20	16	12	16
Elmendorf Tear Strength	—	gms	20	25	100	100	150	160	180	170	160
Edge Tear Resistance	D1004-49-T	lbs/in.					1450	1250	1200	1150	1450
Flammability Rate	D568-56T	Rating	non-burn.	non-burn.	non-burn.	self-ext. (smothers)	Burning	Self-ext. (drips off)	Burning	Self-ext. (drips off)	Burni
Flammability Rate (SPI)	D1433-58	sq. in./min. in/sec.	— .55	— .75	— .25	1 .30	40 0.55	0 0.35	35 0.45	0 0.35	45 0.60
Tensile Heat Distortion Temperature	at 2% Extension at 50% Extension	°C °C	140 175	135 170	130 165	125 160	105 140	105 125	110 145	110 140	110 150
Heat Shrinkage	48 hr. at 120°F. 48 hr. at 240°F.	% %	0.17 1.3	0.24 2.2	0.21 0.8	0.25 1.7	0.45 4.1	0.10 5.2	0.30 3.9	0.15 3.3	0.35 4.4
Total Light Transmission	D672-45T	%	92	92	91	91	91	91	91	91	91
Haze (Kline-Bowen)	D672-45T	%	2	2	3	3	3	3	3	3	3
Refractive Index	D542-42	(air = 1)	—	—	—	—	1.496	1.498	1.490	1.492	1.490
Specific Gravity	D792-44T at 23°/23°C	—	1.31	1.31	1.31	1.31	1.29	1.32	1.29	1.30	1.29
Water Vapor Transmission	F96-53T 0-50% RH, 73°F 50-100% RH, 73°F 0-90% RH, 100°F	g/24 hr/sq.m.	— 45 200 550	— 40 175 500	— 15 75 190	— 13 65 170	— 30 70 190	— 25 65 170	— 30 75 190	— 25 65 160	— 30 75 200
Moisture Absorption	48 hr, 50% RH, 73°F 48 hr, 90% RH, 73°F	% %	2.0 6.0	1.5 5.5	2.0 5.5	1.5 5.0	1.5 4.5	1.5 4.5	1.5 4.5	1.5 4.5	1.5 4.5
Water Absorption	D570-54T	%	7.5	6.5	7.5	6.5	6.0	6.5	6.5	6.0	6.5

● To the best of our knowledge the information contained herein is accurate. However, neither Celanese Corporation of America nor any of its affiliates assu any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of the suitability of any information material for the use contemplated, the manner of use and whether there is any infringement of patents is the sole responsibility of the user.

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We offer technical service for all our plastics. Our experience ranges from the earliest plastics discoveries. A continuous research program is aimed at perfecting formulations and expanding our plastics capabilities. If you have a problem, we may be able to tailor a formulation to satisfy your special needs. Celanese warehouses and facilities at strategic points assure fast deliveries wherever you are located.

CELANESE CORPORATION OF AMERICA, PLASTICS DIVISION, 744 BROAD STREET, NEWARK, N. J.

Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, New York 16, N. Y.

Printed in U.S.A.

Celanese® Fortiflex® Fortic

Taylor Laminated Plastics and Vulcanized Fibre

Basic materials for electrical, electronic and mechanical applications

More than 50 grades to meet any requirement

Take your pick from paper, cotton cloth, nylon, asbestos, glass cloth or other base material impregnated with phenolic, melamine, silicone or epoxy resins and formed into sheets, rods and tubes under heat and pressure.

There is one grade that will fit your exact requirements—whether you need good electrical insulation, great structural strength, resistance to chemical reaction, resistance to heat and flame, ease of fabrication, or a combination of these characteristics.

Phenolic Laminates. Thermosetting type. Paper, cotton fabric or mat, asbestos, glass cloth or nylon bases impregnated with phenol formaldehyde type resins. Provide dependable electrical insulation, have high dielectric and mechanical strength. Some grades are excellent basic materials for gears, cams, pinions, bearings and other mechanical applications. Asbestos grades are qualified as Class B insulation; others meet Class A requirements.

Melamine Laminates. Thermosetting type. Glass cloth or cotton fabric impregnated with melamine formaldehyde resin. These laminates have superior mechanical strength and are especially desirable for their arc resistant qualities. Good flame and heat resistance and good resistance to the corrosive effects of alkalis and most common solvents are other favorable characteristics. Classified as Class B insulation.

Silicone Laminates. Thermosetting type. Continuous filament woven glass fabric impregnated with a silicone resin. These laminates combine high heat resistance (up to 500°F., continuous) with excellent electrical and mechanical properties. Have low power factor and moisture absorption rate; very high insulation resistance and high arc resistance; excellent dimensional stability and high tensile, flexural and impact strength. Classified as Class H insulation.

Epoxy Laminates. Thermosetting type. Continuous filament woven glass fabric or paper impregnated with epoxy resin. Combine low moisture absorption with excellent chemical resistance and high mechanical strength. Characterized by good dielectric strength, low dielectric losses, and high insulation resistance even after being subjected to severe humidity conditions. Can be copper clad for production of high fidelity printed circuits.

Copper-Clad Laminates. Offer a combination of high-purity copper on superior base materials to produce printed circuits of consistently high quality. Taylor copper-clad laminates are available in several phenolic resin, paper base grades, in epoxy resin, paper or glass cloth base grades, and in specially formulated grades to meet specific requirements. All grades meet or exceed military and NEMA standards. The copper cladding is 99.5% pure and free of pinholes, pits and lead inclusions—has a high-quality finish that accepts all acid resists. All Taylor copper-clad laminates are supplied with 1, 2 or 3-oz. copper on one or both sides.

Flame-Resistant Laminates. Flame-retardant paper base laminates made with special phenolic resin. Have excellent moisture resistance, high electrical resistance and good mechanical properties. Offer low dielectric losses. Meet tentative Underwriters' Laboratory requirements for flame retardance.

TAYLOR VULCANIZED FIBRE

Taylor Vulcanized Fibre is a hard, dense material with excellent physical, mechanical and electrical properties. It is tough and resilient; has high resistance to impact, abrasion, wear, organic solvents, oils and gasoline; can be machined, stamped, punched and formed; is attractive in appearance, light in weight. Available in a number of different grades, in sheets, rolls and turned rods: commercial, bone, electrical, trunk, superwhite, built-up, abrasive, flexible, track.•

TAYLOR INSULATION

This material, sometimes called fishpaper, is a highly specialized type of electrical insulation. It has high dielectric strength, is tough and abrasion resistant, has excellent bending properties.

ENGINEERING AND FABRICATING SERVICES

New applications for Taylor materials are constantly being developed by design and production engineers in the Taylor plants. These men are available for consultation. Their experience and counsel can help you in the development of your product. Taylor's fabricating division can economically produce parts from any of the above materials. Consult us for complete details on either one or both of these Taylor services. Technical engineering data on all these products available upon request. Write Taylor Fibre Co., Norristown 45, Pa.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

For more information, turn to Reader Service card, circle No. 454

ARALDITE® EPOXY RESINS PROPERTIES AND APPLICATIONS

		RESIN	RD-1	RD-2	502	506	6005	60
PROPERTIES	(TYPICAL VALUES)	epoxy content						
		1. epoxy value (equivalent/100 g resin)	0.70	0.75	0.38	0.54	0.52	0.51
		2. epoxy equivalent (gms resin/g-mol epoxide)	143	133	263	185	192	196
		esterification equivalent (grams resin esterified by g equiv. acid)	—	—	—	—	—	—
		specific gravity	0.90	1.10	1.15	1.13	1.16	1.16
		color (Gardner)	<1	5	3	2	2	2
		melting point (Durrans) °C.	(liquid)	(liquid)	(liquid)	(liquid)	(liquid)	(liqui
		viscosity (at 25°C.) Brookfield (cps)	3	19	3,000	800	9,500	14,0
		Gardner-Holdt	—	—	—	—	Z_4	Z_5
STRUCTURAL		Adhesives		✓	✓		✓	✓
		Body "Solders"	✓	✓	✓	✓	✓	✓
		Casting	✓	✓	✓	✓	✓	✓
		Caulking and Sealants	✓	✓	✓	✓	✓	✓
		Electrical	✓	✓	✓	✓	✓	✓
		Impregnating	✓	✓	✓	✓	✓	✓
		Laminating	✓	✓	✓	✓	✓	✓
		Tooling	✓	✓	✓	✓	✓	✓
COATINGS	MAINTENANCE	Equipment Finishes						
		Marine Finishes						
		Masonry Finishes			✓			
		Structural Steel Coatings						
		Tank Coatings						
	PRODUCT FINISHING	Aircraft Finishes						
		Appliance Primers						
		Automotive Primers						
		Can & Drum Linings						
		Chemical Resistant Finishes			✓			
		Collapsible Tube Coatings						
		Furniture Finishes						
		Metal Decorating Finishes						
		Pipe & Tank Linings						
	TRADE SALES	Concrete Floor Paints						
		Gym and Floor Varnishes						
		Spar Varnishes						
OTHER USES		Decorative Flooring—Epoxy/Marble Chip *(Terrazzo)			✓			
		Floor Topping—Industrial	✓	✓	✓	✓		
		Printing Inks						
		Road Toppings			✓			
		Vinyl Stabilizers				✓		

● In U.S.A. and Canada CIBA produces basic resins only, to be formulated for intermediate and end uses.

* Available as ARALDITE Resin Solutions for the convenience of the formu

† 40% N.V. solution in Butyl "Carbitol."

‡ Used primarily in conjunction with fatty acids to produce esters.

CIBA manufactures a wide range of epoxy resins, hardeners, and modifiers to suit every application requirement. The chart below summarizes typical specification data and recommended end uses.

C I B A

FIRST IN EPOXIES

6020	6030	6040*	6060	6071*	6075	6084†	6097*	6099	7071*	7097*
0.48	0.44	0.37	0.24	0.205	0.14	0.105	0.046	0.033	0.205	0.058
208	227	270	417	485	715	950	2200	3200	485	1800
—	—	—	—	130	185	175	190	200	—	—
1.16	1.16	1.16	1.19	1.21	1.19	1.15	1.15	1.19	1.22	1.14
3	5	6	4†	4†	4†	4	5†	5†	4	4
(liquid)	(liquid)	31	67	70	83	100	130	150	70	115
18,000	40,000	> 100,000	—	—	—	—	—	—	—	—
Z_4	A_2†	A_1†	D†	E†	L†	S†	Z†	Z_2†	E†	X-Y
✓	✓	✓	✓	✓	✓				✓	
✓										
✓			✓							
✓										
✓			✓						✓	
✓			✓	✓	✓		✓			✓
✓				✓					✓	
				✓		✓			✓	
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						✓				
					✓		✓	✓		✓
				✓			✓	✓	✓	✓
					✓					
				✓			✓		✓	✓
					✓	✓	✓			✓
							✓	✓		✓
				✓		✓			✓	
						✓				
						✓				
✓										
						✓				
	✓									

CIBA will be pleased to provide further information on the use of ARALDITE Epoxy Resins in specific fields of use.

For more information, turn to Reader Service card, circle No. 552

CIBA Products Corporation **MDE-SE10-9**
Fair Lawn, New Jersey

Please send me further information on the use of ARALDITE Epoxies for the following applications:

NAME
COMPANY TITLE
ADDRESS
CITY STATE

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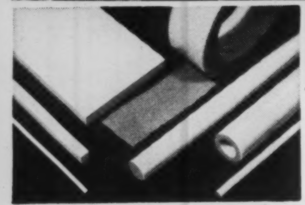
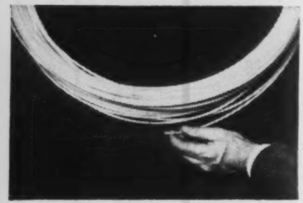
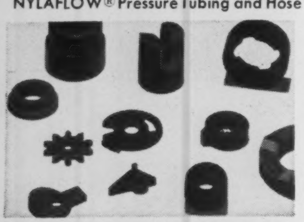
. . . where the house-mark is undeviating quality!



Stock Shapes—for rapid, low-cost fabrication
POLYPENCO Nylon and NYLATRON® GS
POLYPENCO Teflon† TFE
POLYPENCO Q-200.5 (cross-linked styrene)
POLYPENCO K-51 Penton⁺
POLYPENCO LEXAN⁺⁺



NYLAFLOW® Pressure Tubing and Hose



Molded Parts—FLUOROSINT* TFE fluorocarbon resin
NYLASINT® cold pressed and sintered parts

● When it comes to the really demanding jobs for industrial plastics—where deviation from the highest uniform quality may mean trouble—it pays to specify POLYPENCO. Solve your problems of in-plant production and end-product reliability today with the consistent high quality of POLYPENCO plastics, processed for uniformity in physical, chemical and electrical properties.

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NYLATRON® GS
Nylon Molding Powders

CORVEL®
Fusion Bond Finishes

POLYPENCO®

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*Trademark of The Polymer Corporation
†DuPont trademark for fluorocarbon resins
⁺Hercules Powder Co. trademark for chlorinated polyether resins
⁺⁺General Electric Co. trademark for polycarbonate resins

For more information, turn to Reader Service card, circle No. 610

For more information, circle No. 623 ➤

PLASTICS
CHARACTERISTICS FROM
CYANAMID

CYMEL®

(THERMOSETTING) MELAMINE FORMALDEHYDE MOLDING COMPOUND

Cymel molding compounds fill a variety of industrial and consumer applications—all have basic properties of surface hardness; non-flammability; resistance to heat, boiling water and attack by solvents; color stability; lack of odor or taste, and good electrical properties—for compression, transfer or plunger molding. *Military and Federal specifications are listed on technical data sheets, available on request.*

CYMEL 1077-1079 — alpha cellulose-filled — granular or powdered material available in extraordinary surface hardness — rich, lustrous look and feel — excellent chemical resistance—excellent electrical properties, including arc and track resistance . . . *dinnerware, buttons, electric mixer and shaver housings, closures, lighting fixtures.*

CYMEL 592 — asbestos-filled — granular material, available in brown only — excellent arc resistance and dielectric strength at elevated temperatures—dimensional stability—resistance to atmospheric extremes . . . *electronic equipment, aircraft and automotive ignition parts, circuit breakers, terminal blocks, switch gears.*

CYMEL 1500 — wood flour-filled — granular material, available in brown only—general purpose arc resistant electrical grade material—excellent dielectric strength . . . *watt-hour meter blocks, connector plug inserts, automotive ignition parts.*

CYMEL 1502 — cellulose-filled — granular material, available in brown only—particularly good dimensional stability and dielectric strength—excellent insert retention . . . *connector plug inserts, circuit breakers, automotive ignition parts, watt-hour meter blocks.*

CYMEL 3135 — glass fiber-filled — coarse-chopped material, natural color — electrical grade, high impact resistance — extraordinary flame resistance—arc resistant—low shrinkage and moisture absorption . . . *heavy duty switch gears, terminal strips and stand-off insulators, sockets and coil forms.*

CYMEL 3136—glass fiber-filled—granular material, natural color—electric grade material with intermediate strength—excellent arc and insulation resistance—extraordinary flame resistance—low shrinkage and moisture absorption . . . *terminal strips and stand-off insulators, sockets and coil forms.*

CYMEL 3020—cotton fabric-filled—chopped cotton, available in black only—electrical grade material with medium impact resistance—very good arc resistance, heat resistance and chemical resistance . . . *terminal strips, circuit breakers.*

CYMEL 404 — unfilled — highly translucent, may be tinted before molding—high surface luster . . . *decorative moldings including buttons and jewelry findings.*

BEETLE®

(THERMOSETTING) UREA-FORMALDEHYDE ALPHA CELLULOSE-FILLED MOLDING COMPOUNDS

Beetle molding compounds produce marproof, lustrous moldings highly resistant to detergents, oils and greases—they are supplied in powder or granular form and various plasticities to meet specific molding needs in compression molding.

BEETLE is formulated to meet these specifications: Federal L-P-406b, LC 726-1, ASTM D705-55, Grade 1 (Arc resistance limits are in process of revision by ASTM). Characteristics: unlimited range of lustrous colors, smooth, hard surface, odorless and tasteless, stain-resistant, wear-resistant, arc-resistant, track-resistant, good dielectric strength, durable. Applications: radio cabinets, stove hardware, wiring devices, electric appliance housings, cosmetic containers, closures, buttons.

PLASTICS

CHARACTERISTICS FROM CYANAMID

LAMINAC®

POLYESTER RESINS

Laminac thermosetting resins vary in viscosity, rate of cure, degree of reactivity and degree of rigidity of the cured product – flexible or rigid laminates can be produced by the proper choice of resins – they are clear, nearly colorless liquids – when cured resist heat and chemicals.

LAMINAC 4101 – medium viscosity, general purpose rigid resin developed for compression molding of reinforced trays, boxes, housings and similar products.

LAMINAC 4103 – medium reactivity, resilient resin – ideal for hot-press molding of products required to withstand heavy mechanical abuse – boats, auto bodies and truck cabs.

LAMINAC 4105 – medium reactivity, slightly thixotropic resin – for boat builders and other fabricators using hand lay-up techniques – no sagging, rigid and fast curing.

LAMINAC 4106 – medium reactivity, slightly thixotropic resin – comparable in performance to Laminac 4105 but formulated specifically for use with resin-fiber depositor spray guns.

LAMINAC 4107 – high reactivity, medium viscosity resin – rigid and chemical resistant – suitable for fast high temperature molding as well as for other fabricating methods.

LAMINAC 4109 – medium viscosity, maximum chemical resistance – excellent electrical properties and good hot strength.

LAMINAC 4110 – low viscosity – cures tack free at room temperature – for boats and prototypes.

LAMINAC 4111 – low viscosity, highly reactive resin – maximum chemical resistance and excellent electrical properties – for storage containers, electric and electronic parts.

LAMINAC 4116 – low reactive, general purpose resin – recommended for strength, rigidity and water resistance – for fishing rods, mannequins, radomes, castings (Laminac 4134 may be added for improved resilience).

LAMINAC 4119 – formulated for resistance to mild chemical solutions at temperatures below 120° F – for tanks or storage containers.

LAMINAC 4120 – fast curing, highly reactive, high viscosity resin – suitable for compounding with fillers and with color pastes for obtaining glossy resin rich surfaces.

LAMINAC 4123 – intermediate reactivity, general purpose resin – medium viscosity, useful in either high or low temperature applications for suitcases, chairs, safety helmets.

LAMINAC 4128 – low viscosity, highly reactive resin for hand lay-up or presswork – good hot strength – for aircraft accessories such as junction boxes, fuel tanks.

LAMINAC 4131 – fast curing, excellent moldability – intended for compounding with fillers and fiber reinforcement for premix molding compounds – good fiber-wetting – low density – molded parts have good hot strength and good resilience.

LAMINAC 4134 – low viscosity, flexible resin used in combination with rigid resins to improve impact and shock resistance.

LAMINAC 4146 – for production of self-extinguishing fibrous glass reinforced laminates and moldings – for motor housings under continuous heat, aircraft parts, hot air ducts.

LAMINAC 4192 – for maximum resistance to discoloration on exposure to light – used for the production of flat or corrugated sheeting.

LAMINAC 4202 – high viscosity liquid resin – unusually long catalysed stability – odor free – cures at temperatures above 200°F – for large radomes and aircraft shelters.

LAMINAC 4232 – exceptionally stable at elevated temperatures when properly cured – for production of critical parts that are required to retain strength at high temperatures.

LAMINAC 4233 – similar in characteristics to 4232 plus self-extinguishing properties.

CYANAMID

AMERICAN CYANAMID COMPANY • PLASTICS AND RESINS DIVISION

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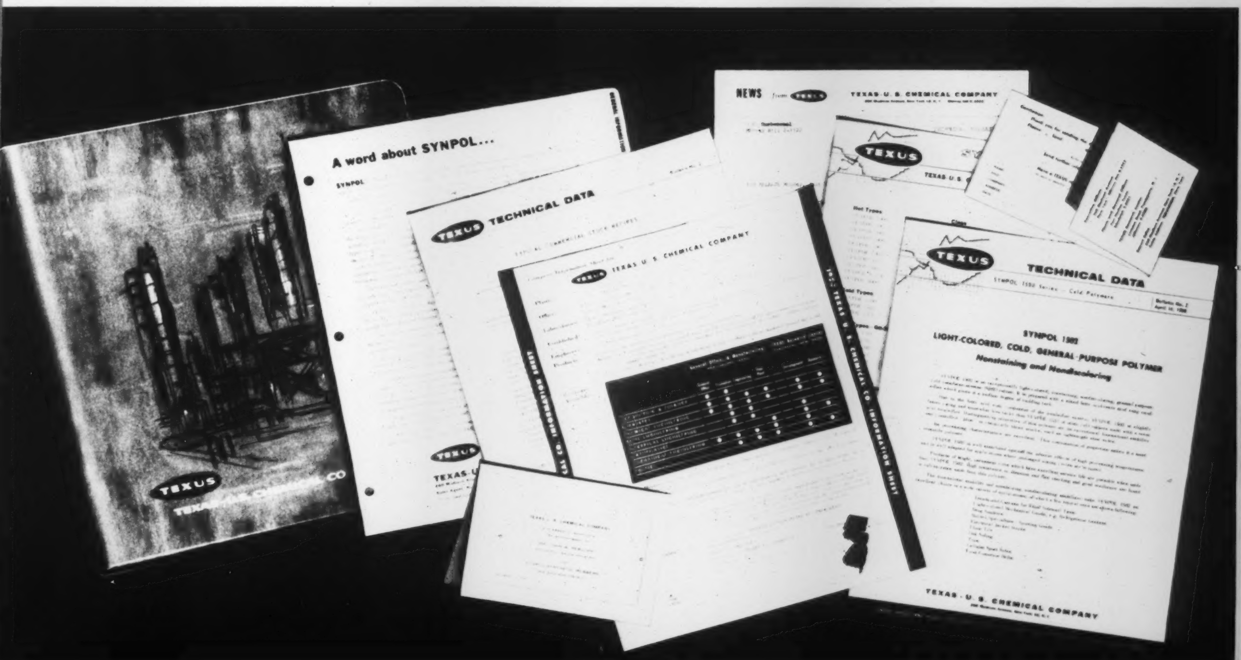
SBR

STYRENE-BUTADIENE RUBBER

Have you thoroughly considered

SYNPOL


NEWS from TEXUS
TEXAS-U. S. CHEMICAL COMPANY
A word about SYNPOL...
TEXUS TECHNICAL DATA
TEXAS U. S. CHEMICAL COMPANY
INFORMATION SHEET
TEXUS TECHNICAL DATA
SYNPOL 1502
LIGHT-COLORED, COLD, GENERAL-PURPOSE POLYMER
Nonstaining and Nondiscoloring
TEXAS-U. S. CHEMICAL COMPANY
TEXUS
TEXAS U. S. CHEMICAL CO

TEXUS

SYNPOL

HOT TYPES

	1000	1001	1002	1006	1007	1009	1012
DESCRIPTION							
Emulsifier	Fatty Acid	Fatty Acid	Rosin Acid	Fatty Acid	Fatty Acid	Fatty Acid	Fatty Acid
Stabilizer	Staining	Slightly Staining	Staining	Non-Staining Non-Discoloring	Staining	Non-Staining Non-Discoloring	Non-Staining Non-Discolor
Coagulant	Salt Acid	Salt Acid	Salt Acid	Salt Acid	Glue Acid	Salt Acid	Salt Acid
Polymer							
Oil							
Carbon Black							
PROPERTIES							
CHEMICAL	**Specifications**	**Specifications**	**Specifications**	**Specifications**	**Specifications**	**Specifications**	**Specification**
Volatile Matter % wt	0.50 (Max.)	0.50 (Max.)	0.50 (Max.)	0.50 (Max.)	0.50 (Max.)	0.75 (Max.)	0.50 (Max.)
Ash % wt.	1.50 (Max.)	1.50 (Max.)	1.50 (Max.)	1.50 (Max.)	0.50 (Max.)	1.50 (Max.)	1.50 (Max.)
Organic Acid % wt.	4.00–6.25	4.00–6.25	3.75–6.00	3.75–6.00	3.75–6.00	3.75–6.00	4.25–6.50
Soap % wt.	0.75 (Max.)	0.75 (Max.)	0.75 (Max.)	0.75 (Max.)	0.25 (Max.)	0.75 (Max.)	0.50 (Max.)
Bound Styrene % wt.	22.5–24.5	22.5–24.5	22.5–24.5	22.5–24.5	22.5–24.5	22.5–24.5	22.5–24.5
Stabilizer % wt.	1.00–1.75	1.00–1.75	1.00–1.75	1.25 added	1.00–1.75	1.25 added	1.25 added
Carbon Black % wt.							
PHYSICAL	**Specifications**	**Specifications**	**Specifications**	**Specifications**	**Specifications**	**Specifications**	**Specifications**
Raw Viscosity, ML-4′–212° F.	44–52	44–52	50–58	46–54	45–55		95–115
Cpd. Viscosity, ML-4′–212° F.	73 (Max.)	73 (Max.)	65 (Max.)	73 (Max.)	73 (Max.)	115–135	120 (Max.)
Tensile psi 50′	2700 (Min.)	2500 (Min.)	2700 (Min.)	2500 (Min.)	2400 (Min.)	1600 (Min.)	2900 (Min.)
Elongation % 50′	550 (Min.)	500 (Min.)	550 (Min.)	500 (Min.)	500 (Min.)	300 (Min.)	450 (Min.)
=**Modulus** psi 25′	300–600	325–625	300–600	400–700	450–750	400–700**	550–1000
=**Modulus** psi 50′	800–1150	750–1100	750–1100	825–1175	775–1125	600–950**	1200–1700
=**Modulus** psi 100′	1250–1650	1200–1600	1125–1525	1300–1700	1125–1525	850–1250**	1750–2250
Water Soluble Ash % wt.					0.35 (Max.)		
Water Absorption mg./sq. cm.					1.50 (Max.)		
Mill Shrinkage % linear						25.0 (Max.)	
TEST RECIPES[1]							
Polymer or Masterbatch	100.00	100.00	100.00	100.00	100.00	100.00	100.00
EPC Black	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Zinc Oxide	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Sulfur	2.00	2.00	2.00	2.00	2.00	1.50	2.00
Benzothiazyldisulfide	1.75	1.75	3.00	1.75	1.75	1.75	1.75
Stearic Acid			1.50				
REMARKS	A general purpose hot rubber adaptable to most black products where color is unimportant.	General purpose hot rubber which is more resistant to staining and discoloring than 1000.	A general purpose hot rubber exhibiting greater building tack than 1000 or 1001.	A general purpose light-colored hot rubber; non-discoloring and non-staining.	Glue acid coagulated staining polymer with relatively low water absorption, low ash, and good electrical properties.	A non-staining cross linked divinylbenzene terpolymer. Use of small quantities with other type polymers reduces shrinkage and die-swell in calender and extrusion operations.	A high-Mooney polymer particularly suited for solution applications.
APPLICATIONS	Molded and extruded mechanical goods, shoe soles and heels, tires, and any other general purpose application.	Tires, molded and extruded mechanical goods, shoe soles & heels.	Molded and extruded mechanical goods, tires.	Light-colored and white products, such as white sidewall tires, shoe soles, floor tile, toys, hospital sheeting, sporting goods, high-impact styrene.	Wire & cable insulation and jacketing, electrical tape, gaskets, hard rubber products, etc.	Where control of shrinkage is important. Footwear, wire & cable insulations, calendered goods, soles, heels. Can be used with Natural Rubber and Neoprene.	Asbestos sheet packing. Specia types of adhesives and certain mechanical goods.

[1] The figures given are parts by weight of NBS Standard Compounding Ingredients. Press cure at 292° F.

=300% Elongation †Based on rubber hydrocarbon content **Synpol 1009 Moduli @ 200% Elongation

Consider SYNPOL for

Quality

Hundreds of the country's most experienced and exacting rubber processors can attest to the fact that there are no higher quality rubbers in the industry. Employment of the most advanced and most comprehensive quality controls, including a number pioneered by TEXUS—such as the large-scale use of stainless-steel processing equipment and establishment of a special management-directed quality enforcement system—assures the highest degree of purity and uniformity.

Variety

There are now 25 separate and distinct grades of SYNPOL, including a rubber for practically every purpose and processing requirement. In addition to offering the many standard grades of hot, cold, and cold oil-extended rubbers, TEXUS has pioneered in the development of the extremely light-colored, non-staining polymers. SYNPOLS were also the first commercially proved ultra-dispersed, mechanically mixed black masterbatches available in large volume to the rubber industry.

Delivery

The most comprehensive warehousing operation in the industry enables TEXUS to provide a level of fast, efficient delivery that is *unmatched*. Six strategically located warehouses—Providence, R. I., Edgewater, N. J., Akron, O., Chicago, Ill., Los Angeles, Calif., Port Neches, Tex.—permit over-night deliveries. Because you get the rubber you want *when* you want it, even in truckload quantities at no premium, you can enjoy lower on-hand and in-transit inventories at no sacrifice in operating efficiency.

Technical Service...backed by Effective Research

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SYNPOL®

COLD TYPES

COLD

1061	X-274	8000	1500	1502	1551	1703	1707	1708	
Fatty Acid Non-Staining Non-Discoloring Salt Acid	Rosin Acid Slightly Staining Salt Acid	Fatty Acid Non-Staining Non-Discoloring Salt Acid	Rosin Acid Staining Salt Acid	Mixed Acid Non-Staining Non-Discoloring Salt Acid	Rosin Acid Non-Staining Non-Discoloring Salt Acid	Mixed Acid Non-Staining Non-Discoloring Salt Acid Polymer—100 pts. NAPH—25 pts.	Rosin Acid Non-Staining Non-Discoloring Salt Acid Polymer—100 pts. NAPH—37.5 pts.	Fatty Acid Non-Staining Non-Discoloring Glue Acid Polymer—100 pts. NAPH—37.5 pts.	Ro St Sa Po H
Specifications 0.50 (Max.) 1.50 (Max.) 4.00–6.25 0.75 (Max.) 22.5–24.5 1.25 added	**Specifications** 0.50 (Max.) 1.50 (Max.) 3.75–6.00 0.75 (Max.) 22.5–24.5 1.00–1.75	**Tentative Specifications** 1.00 (Max.) 1.25 (Max.) 4.00–6.00 0.75 (Max.) 42.0–45.0 1.25 added	**Specifications** 0.75 (Max.) 1.50 (Max.) 5.00–7.25 0.50 (Max.) 22.5–24.5 1.00–1.75	**Specifications** 0.75 (Max.) 1.50 (Max.) 4.75–7.00 0.50 (Max.) 22.5–24.5 1.25 added	**Specifications** 0.75 (Max.) 1.50 (Max.) 5.00–7.25 0.50 (Max.) 22.5–24.5 1.25 added	**Specifications** 0.75 (Max.) 1.50 (Max.) 4.50–6.30 0.50 (Max.) 22.5–24.5 1.25 added†	**Specifications** 0.75 (Max.) 1.50 (Max.) 3.90–5.70 0.50 (Max.) 22.5–24.5 1.25 added†	**Specifications** 0.75 (Max.) 0.50 (Max.) 3.90–5.70 0.50 (Max.) 22.5–24.5 1.25 added†	**Sp** 0. 1. 3. 0. 22 1.
Specifications 44–52 73 (Max.) 2500 (Min.) 500 (Min.) 325–625 750–1100 1200–1600	**Specifications** 50–60 65 (Max.) 2500 (Min.) 500 (Min.) 300–600 750–1100 1125–1525	**Typical Production Values** 45 47 2990 630 460 970 1600	**Specifications** 46–58 73 (Max.) 3800 (Min.) 600 (Min.) 300–650 800–1200 1200–1700	**Specifications** 46–58 73 (Max.) 3100 (Min.) 575 (Min.) 350–650 775–1125 1250–1650	**Specifications** 46–58 73 (Max.) 3600 (Min.) 600 (Min.) 300–650 800–1200 1200–1700	**Typical Production Values** 57 54 3360 680 410 820 1210	**Typical Production Values** 52 45 3000 820 200 510 850	**Typical Production Values** 54 52 3260 690 460 760 1060 0.35 (Max.) 1.50 (Max.)	**Typ** **duc** 51 44 309 810 190 490 810
100.00 40.00 5.00 2.00 1.75	100.00 40.00 5.00 2.00 3.00 1.50	100.00 40.00 5.00 2.00 1.75	100.00 40.00 5.00 2.00 3.00 1.50	100.00 40.00 5.00 2.00 2.00	100.00 40.00 5.00 2.00 3.00 1.50	100.00 40.00 5.00 2.00 3.00	100.00 40.00 5.00 2.00 2.75 1.50	100.00 40.00 5.00 2.00 2.75	100 40. 5.0 2.0 2.7 1.5
A non-staining, non-discoloring polymer, stabilized for maximum resistance to breakdown and gel formation during milling.	Contains a slightly staining stabilizer and rosin acid soap.	A very light-colored, high styrene (43.5 parts) polymer. Non-staining and non-discoloring. A modification of 1013.	A general purpose cold rubber for use where color and staining are unimportant.	Non-discoloring and non-staining cold rubber. Higher physicals than 1006 and 1061.	A general purpose non-staining and non-discoloring cold rubber. It is similar to 1502 but has better building tack.	A general purpose non-discoloring, non-staining oil-extended polymer.	An oil-extended general purpose polymer designed to give better building tack and greater economy.	Non-discoloring and non-staining polymer; low ash content and water absorption values, giving good electrical properties.	A ge stai desi proc bett tack
Light-colored & white products such as white sidewall tires, shoe soles, floor tile, toys, hospital sheeting, sporting goods, high-impact styrene.	Similar to 1001 and 1002. Designed for use in compounding special sealant formulations.	Calendered goods, closures, can sealants, adhesives and molded goods. Designed for applications requiring high green strength and excellent flow characteristics.	Tires, camelback, molded and extruded mechanical goods.	Light-colored & white products such as white sidewalls, light mechanicals, floor tile, hospital sheeting, toys, soles, heels, food conveyor belts, high-impact styrene.	Light-colored & white products such as white sidewalls, white & light-colored mechanicals, floor tile, hospital sheeting, toys, soles, heels, food conveyor belts.	Light-colored and white products; tires, mechanical goods, floor tile, matting, shoe soles and heels sporting goods and toys.	White sidewall tires, camelback, molded and extruded mechanical goods. Friction and skin coats. Molded shoe soles and heels.	Wire & cable insulation and jacketing, certain electrical goods, coated fabrics, molded and extruded mechanicals, soles, heels, wringer rolls, matting.	Tires came mold extru anica

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OIL-EXTENDED TYPES					BLACK MASTERBATCHES ULTRA-DISPERSED			
1711	1712	8200	8201	8202	8150	8253	8254	8266
sin Acid ining t Acid ymer—100 pts. AR—37.5 pts.	Mixed Acid Staining Salt Acid Polymer—100 pts. HI-AR—37.5 pts.	Fatty Acid Non-Staining Non-Discoloring Glue Acid Polymer—100 pts. NAPH—37.5 pts.	Fatty Acid Non-Staining Non-Discoloring Glue Acid Polymer—100 pts. NAPH—50 pts.	Mixed Acid Staining Salt Acid Polymer—100 pts. HI-AR—50 pts.	Rosin Acid Staining Acid Polymer Type 1500 — 100 pts. HAF — 50 pts.	Rosin Acid Non-Staining Non-Discoloring Acid Polymer Type 1707 — 100 pts. NAPH — 37.5 pts. FEF — 60 pts.	Mixed Acid Staining Acid Polymer Type 1712 — 100 pts. HI-AR — 37.5 pts. HAF — 75 pts.	Rosin Acid Staining Acid Polymer Type 1711 — 100 pts. HI-AR — 37.5 pts. ISAF — 75 pts.
ecifications 5 (Max.) 0 (Max.) 0–5.70 0 (Max.) 5–24.5 25 added†	Specifications 0.75 (Max.) 1.50 (Max.) 3.90–5.70 0.50 (Max.) 22.5–24.5 1.25 added†	Tentative Specifications 0.75 (Max.) 0.50 (Max.) 3.90–5.70 0.50 (Max.) 22.5–24.5 1.25 added†	Tentative Specifications 0.75 (Max.) 0.50 (Max.) 4.10–5.70 0.50 (Max.) 22.5–24.5 1.25 added†	Tentative Specifications 0.75 (Max.) 1.50 (Max.) 4.70–6.20 0.75 (Max.) 22.5–24.5 1.25 added†	Specifications 1.00 (Max.) 0.50 (Max.) 3.25–4.75 0.50 (Max.) 1.25 added† 32.4–34.2	Tentative Specifications 1.00 (Max.) 0.50 (Max.) 2.70–4.00 0.50 (Max.) 1.25 added† 29.1–31.7	Tentative Specifications 1.00 (Max.) 0.50 (Max.) 3.00–4.50 0.50 (Max.) 1.25 added† 33.9–36.6	Tentative Specifications 1.00 (Max.) 0.50 (Max.) 3.00–4.50 0.50 (Max.) 1.25 added† 33.9–36.6
cal Production Values 0	Typical Production Values 53 49 3230 710 230 580 870	Typical Production Values 56 58 2550 520 700 1100 1350 0.78	Typical Production Values 55 49 2930 690 480 720 1030 0.78	Typical Production Values 49 43 2900 750 240 560 860	Specifications 65–80 3000 (Min.) 350 (Min.) 1325–2125 1750–2650 2100–3100	Typical Production Values 48 2560 610 990 1190 1360	Typical Production Values 67 2990 600 760 1350 1890	Typical Production Values 65 2990 600 670 1200 1770
00 0	100.00 40.00 5.00 2.00 2.75	100.00 40.00 5.00 2.00 2.75	100.00 40.00 5.00 2.00 2.75	100.00 40.00 5.00 2.00 2.75	150.00 5.00 2.00 2.00 1.50	144.00 5.00 2.00 2.00 1.50	154.50 5.00 2.00 1.00	154.50 5.00 2.00 1.00 1.50
eral purpose ing polymer ned for easy essing and r building	General purpose, easy processing, oil-extended polymer for use where color and staining are unimportant.	An oil-extended polymer, especially designed to give extremely high resistance to discoloration and staining. Low ash and low moisture absorption properties.	Non-discoloring, non-staining polymer, with low ash content and water absorption values giving good electrical properties. High oil-extension results in low-cost compounds.	General purpose highly extended polymer for maximum compounding economy where color and staining are unimportant.	A general purpose, staining cold rubber, containing high-abrasion HAF black.	A non-staining, oil-extended masterbatch which contains FEF black for easy processing and fast extrusion.	A general purpose, staining, cold oil-extended rubber black masterbatch, containing high-abrasion HAF black.	Cold, oil-extended, masterbatch, containing ISAF black for outstanding tire tread wear and mechanical goods durability.
and back, d and ded mech- goods.	Tires, camelback, molded and extruded mechanical goods.	For use in light and bright-colored products requiring outstanding sunlight resistance. Low ash content makes it particularly well suited for low-moisture absorption applications.	Wire & cable insulation and jacketing, certain electrical goods, coated fabrics, molded and extruded mechanicals, soles, heels, wringer rolls, matting.	Tires, camelback, molded and extruded mechanical goods.	Tires, camelback, shoe soles and heels, molded mechanicals and sporting goods, cable jacketing, industrial rolls and wire coatings.	Tire sidewalls and carcasses. Mechanical goods.	Tires, camelback, shoe soles & heels, molded mechanical & sporting goods, cable jacketing, industrial rolls, soles and heels.	Tire treads, mechanical goods.

Rubber and Black are mechanically mixed for ultra-dispersion; resulting in significantly improved physicals, with clean handling and substantial mixing economies.

August 1, 1959

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1. SUPER-ACE HARD RUBBER: Finest general-purpose compound . . . among strongest of all plastics. Excellent chemical resistance, high electrical properties warm, smooth, lustrous. Easily machined. Available i molded parts, sheet, rod, tube, etc.

2. TEMPRON HARD RUBBER: For high temperature applications. Stable and rigid to 225 deg. F. and above It's *hard* rubber, based on Buna-N. Excellent chemical oil and moisture resistance, strong, economical. Available in molded parts, sheets, rod, tubes, and handfabricated objects.

3. MAGNON-2 HARD RUBBER: Special electrica compound with high heat, arc and wear resistance. Excellent moisture resistance. Molds easily, even wit complicated inserts. If required, higher strength, dielectric properties, etc., can be compounded.

4. X-2-B HARD RUBBER: Special electrical sheet, ro and tube stock with excellent dielectric qualities. Rigid strong, excellent flow resistance for parts where bot *electrical* and *mechanical* requirements are high. Punche and machines easily.

5. ARIDACE HARD RUBBER: A special tough molding compound with very low moisture absorption an good chemical resistance. Excellent for things like knif handles, knobs, etc.

6. ACE-HIDE: New rubber-plastic blend with widespread applications. Practically indestructible. High impact strength to 10.0 Izod. Excellent chemical resistance Good for molded parts like acid pails, chair arms, gol bag tops, etc., where you want a material that's bot tough and gentle.

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MECHANICAL, ELECTRICAL
and CHEMICAL PROPERTIES

PROPERTIES (Average test values; cover range of manufacturing processes)	1 SUPER ACE (Hard Rubber)	2 TEMPRON (Hard Rubber)	3 MAGNON 2 (Hard Rubber)	4 X-2- (Hard Rub
TENSILE Psi.	8300-9700	7100-8500	4000-4200	6500-8
ELONGATION Percent	4.0-5.5	2.70-4.0	1.40-1.70	3.80-5.
SPECIFIC GRAVITY	1.17-1.21	1.24-1.29	1.93-1.96	1.24-1.
HARDNESS Shore D	80-88	84-90	85-95	80-8
HARDNESS Rockwell	110-72 to 115-80	95-79 to 115-85	60-38 to 63-41	120-70 125-75
IZOD IMPACT STRENGTH Ft.-lb./in. notch	0.45-0.48	0.24-0.41	0.30-0.34	0.45-0.
FLEXURAL STRENGTH MFS/Psi.	11,300-16,600	11,300-13,000	8200-8400	10,000-15
HEAT DISTORTION TEMP. Deg. F.	135-163	275-300	275-300	150-17
DIELECTRIC STRENGTH 60 Cycles volts/mil	450-575	375-450	500-600	400-45
POWER FACTOR 1 Mc	0.005-0.008	0.014-0.018	0.023-0.027	0.004-0.
DIELECTRIC CONSTANT 1 Mc	2.75-3.00	3.40-3.65	4.70-4.90	3.40-3.
SURFACE RESISTANCE Megohms, 74°F, 86% RH	10^5-10^6	10^3-10^4	10^2-10^3 Arc Resist. 180-190	10^4-10
WATER ABSORPTION % 48 Hrs. at R. T.	0.04-0.06	0.10-0.13	0.05-0.08	0.04-0.
RESISTANCE TO ACIDS Weak Acids Strong Acids	 Excellent Excellent	 Excellent Excellent	 Good Good	 Good Good
RESISTANCE TO ALKALIS Weak Alkalis Strong Alkalis	 Excellent Excellent	 Excellent Excellent	 Good Good	 Good Good
RESISTANCE TO ORGANIC SOLVENTS	Limited	Good	Limited	Limite

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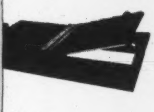
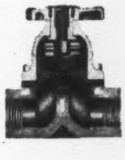


7. RIJI-TUF: Another new rubber-plastic blend . . . harder and more rigid than ACE-HIDE. Impact strength to 4.0 Izod. Has many uses: furniture trim, textile bobbins, bowling pin bases, trays, tool handles, ice cream cabinet lids, tote boxes . . . etc.

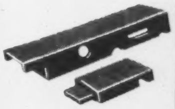
8. ACE SARAN: This general-purpose molding and extruding material is outstanding for chemical and moisture resistance. Handles most inorganic chemicals and organic solvents. Good mechanical properties. Ideal for corrosion-resistant fittings, valves, rayon parts, chemical pipe.



9. PARIAN: One of the finest plastic materials for handling fluids — particularly corrosives — at low temperatures. Has low moisture absorption. High impact strength, even below zero. Odorless, tasteless, non-toxic, hence good for foods. Available in moldings, pipe, fittings, sheet, rod and tube.

10. RIVICLOR: One of the most chemical-resistant thermoplastic materials. Excellent impact resistance. Has good machining and fabricating characteristics and ages well. Available in molded parts, pipe and fittings, linings for tanks, etc.

11. ACE-FLEX: High-impact, chemical-resistant thermoplastic available in flexible tubing and sheet. It's non-toxic, can be steam-sterilized. Excellent for bottle filling machinery, laboratory service lines, hospital equipment, etc. Also good for things like battery separator sheets, etc.



12. ACE-ITE: An interesting new multi-polymer of rubber and plastics. Tough, extremely high impact, with excellent dimensional stability and good chemical resistance. Available in injection and compression-molded parts, machined parts, pipe and fittings.

13. ACE-TUF: A new, reasonably priced rubber-plastic molding material that's tough, strong, dimensionally stable . . . good for literally hundreds of applications. Excellent chemical resistance. Already found to be perfect for things like battery cases, fittings, etc.

5 RIDACE d Rubber)	6 ACE-HIDE (Rubber-Plastic)	7 RIJI-TUF (Rubber-Plastic)	8 ACE SARAN	9 ACE PARIAN (Poly-ethylene)	10 ACE RIVICLOR (Rigid Vinyl)	11 ACE-FLEX	12 ACE-ITE	13 ACE-TUF (Rubber-Plastic)	PROPERTIES (Average test values; cover range of manufacturing processes)
00-5600	1000-2500	2000-3500	4000-7000	1900-3000	8000-8500	1900-3000	4200-5100	1700-2000	TENSILE Psi.
.6-4.0	70-200	2-30	10-40	50-600	7-25	275-390	20-40	6-8	ELONGATION Percent
28-1.32	1.20-1.40	1.20-1.40	1.65-1.75	0.92-1.10	1.35-1.45	1.24-1.35	1.05-1.12	1.28-1.38	SPECIFIC GRAVITY
80-84	50-70	60-75	—	—	—	80-90 (A)	—	68-75	HARDNESS Shore D
16-65 to 20-70	—	—	M50—M65	R25—R35	R90—R120	—	R82—R95	200-70 to 210-75	HARDNESS Rockwell
46-0.50	3.0-10.0	1.0-4.0	0.3-1.0	Over 3.0	0.4-2.5	Flexible	4.3-10.0	0.56-0.64	IZOD IMPACT STRENGTH Ft.-lb./in. notch
00-12,000	3300	4800-7000	15,000-17,000	1500-1700	9000-14,000	Flexible	8000-14,000	4200-4800	FLEXURAL STRENGTH MFS/Psi.
10-120	110-120	125-140	150-180	115-122 (66 psi.)	140-180	Flexible	145-175	120-130	HEAT DISTORTION TEMP. Deg. F.
50-550	400-500	400-500	350-400	600-700	350-425	350-400	300-600	250-390	DIELECTRIC STRENGTH 60 Cycles, volts/mil
05-0.008	0.005-0.0065	0.007-0.020	0.03-0.05	0.0003	0.01-0.03	0.07-0.11	0.05	High	POWER FACTOR 1 Mc
.20-3.60	3.00-3.60	2.70-3.50	3.00-5.00	2.25-2.30	3.10-3.30	4.70-5.50	—	High	DIELECTRIC CONSTANT 1 Mc
10^5-10^6	10^4-10^5	10^4-10^5	Vol. Res. 10^{14}-10^{16} ohms/cm	Vol. Res. 10^{9}-10^{17} ohms/cm	—	—	—	10^4-10^5	SURFACE RESISTANCE Megohms, 74°F, 86% RH
.02-0.04	Very Low	Very Low	0.0-0.1	0.0-0.1	0.07-0.4	0.1-0.4	0.3-0.5	0.2-0.3	WATER ABSORPTION % 48 Hrs. at R. T.
xcellent xcellent	Excellent Good	Excellent Good	Excellent Excellent	Excellent Excellent	Excellent Excellent	Excellent Limited	Excellent Good	Excellent Good	RESISTANCE TO ACIDS Weak Acids Strong Acids
xcellent xcellent	Excellent Excellent	Excellent Excellent	Excellent Good	Excellent Excellent	Excellent Good	Excellent Limited	Excellent Excellent	Excellent Good	RESISTANCE TO ALKALIS Weak Alkalis Strong Alkalis
Limited	Limited	Limited	Good	Good	Good	Good	Limited	Limited	RESISTANCE TO ORGANIC SOLVENTS

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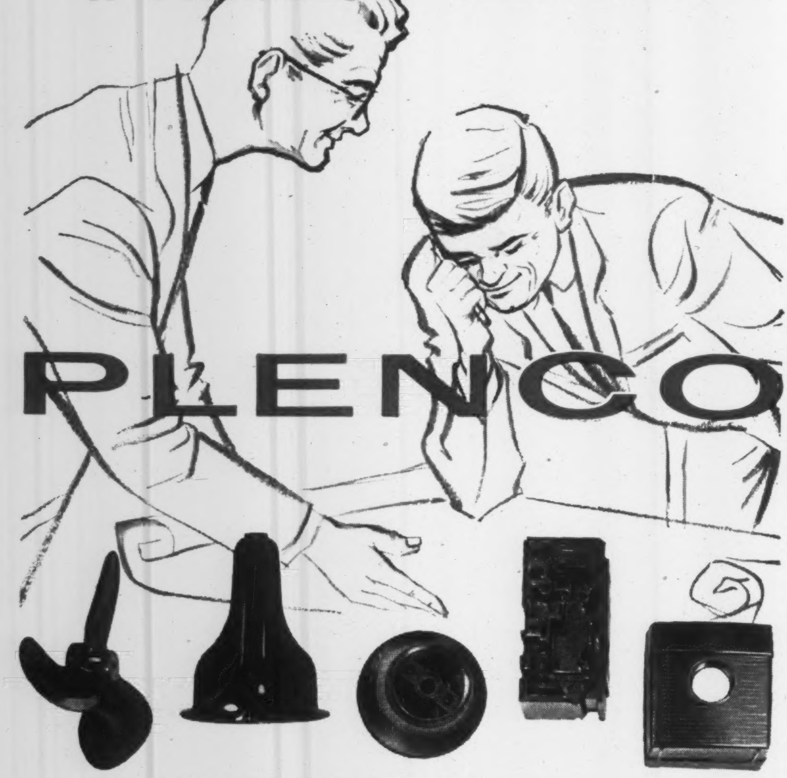

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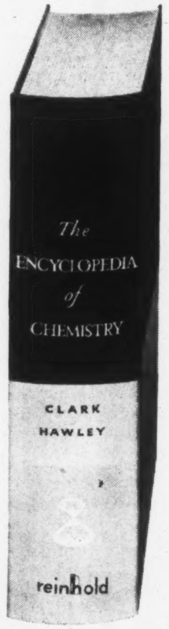

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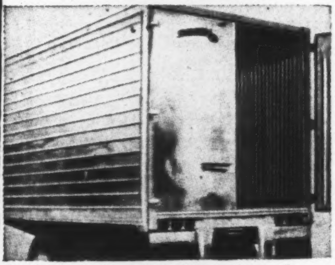

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2029	XXX	3115, Type PBE	Phenolic binder, paper filler. Low dielectric loss, low water absorption. For radio, X-ray, high voltages.
2053	XP	——	Phenolic binder, paper filler. Low cost, high strength mechanical grade. Excellent hot-punching material.
11541	XXP-IR	3115, Type PBE-P	Phenolic binder, paper filler. High insulation resistance, low cost. Excellent hot-punching material.
11570	XXXPC	3115, Type PBE-P	Phenolic binder, paper filler. Best quality paper base. High insulation resistance, low dielectric loss. Can be precision-punched at room temperatures.
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11545	N-1	15074	Phenolic binder, nylon filler. Excellent electrical and good mechanical properties under humid conditions.
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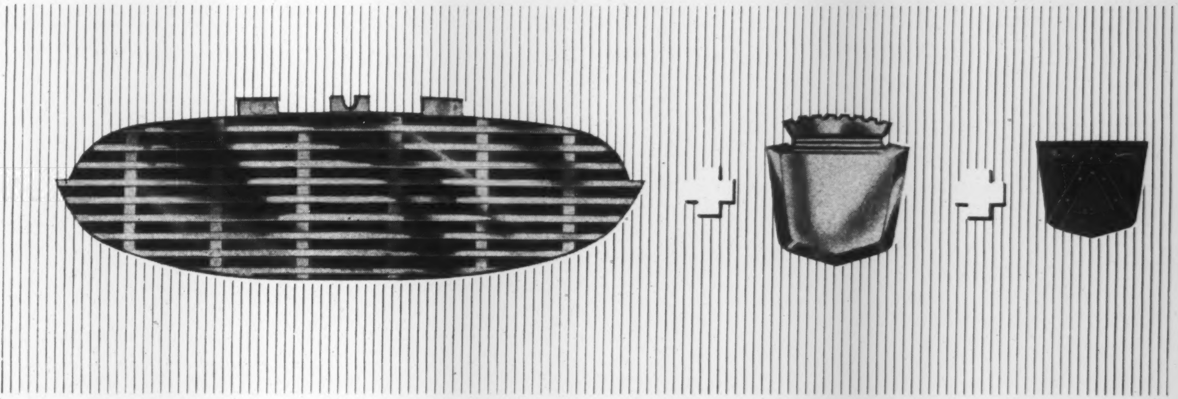
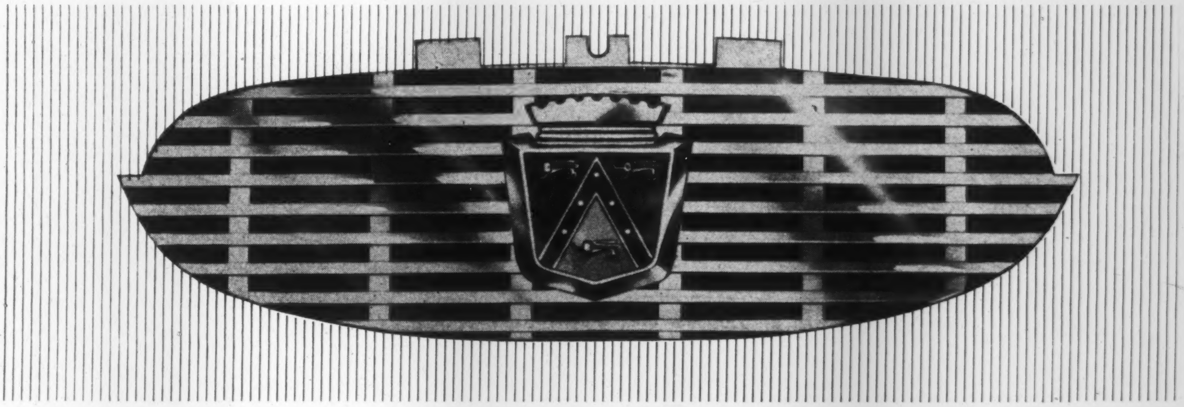


by switching to this 1-piece PLEXIGLAS molding



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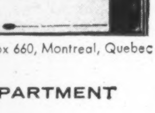

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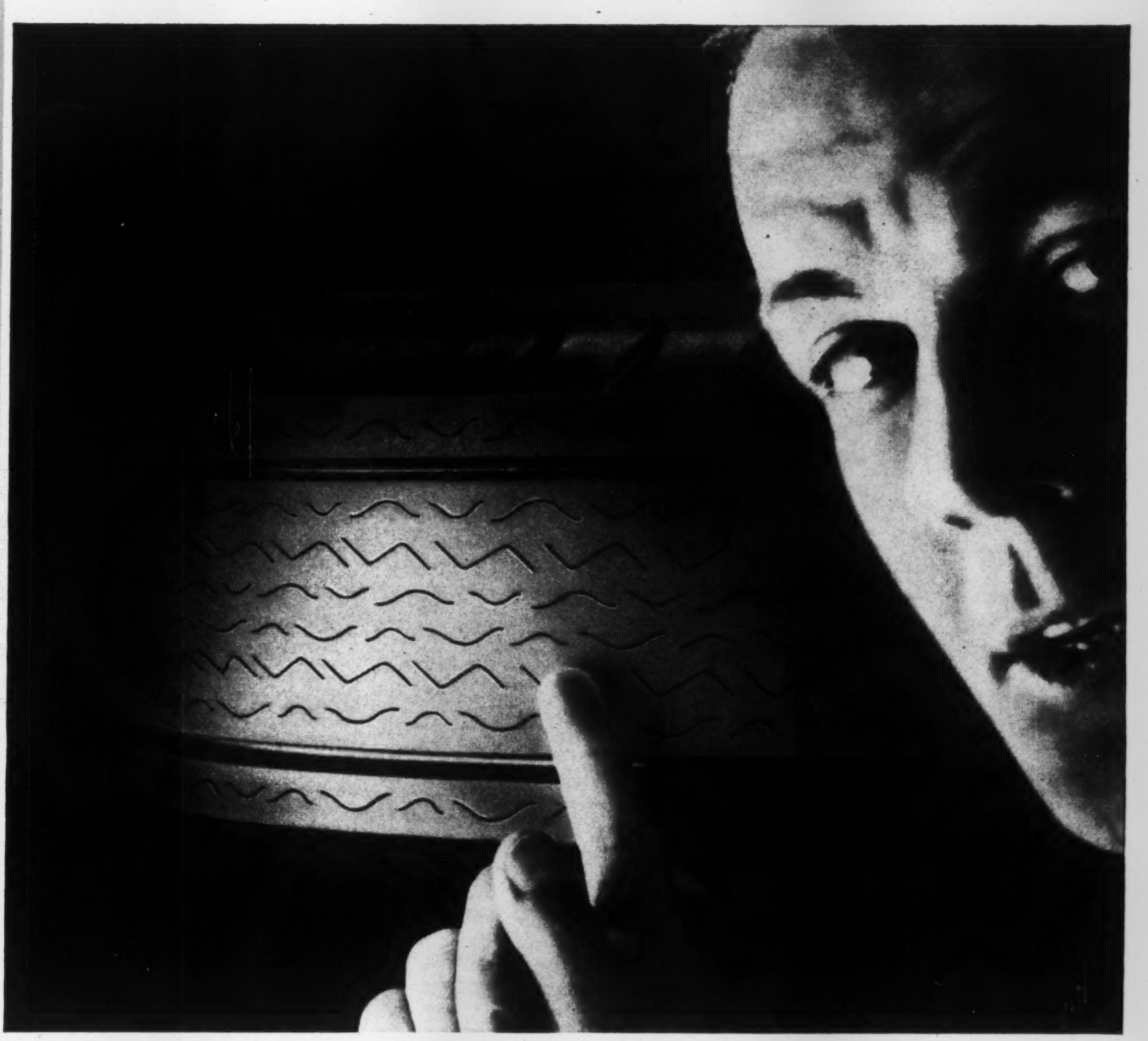

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Engineering Uses of
RUBBER

Edited by
ARCHIBALD T. McPHERSON
Associate Director, National Bureau of Standards, and the late
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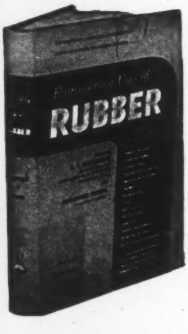

1956
528 pages
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Primarily for engineers outside of the rubber industry who find it necessary to employ rubber in processing operations and in manufactured products. Written by highly competent authorities, McPherson and Klemin's book provides invaluable information on the manufacture of rubber goods, the properties and behavior of rubber, the applications in different industries, methods of obtaining rubber products either by purchase on specifications or by special construction, and the relationships between the structure of polymers and their rubber-like properties. In addition to the engineer directly concerned with the industrial use of rubber, this book will also appeal to rubber chemists and technologists who would like to know more about the end uses to which their product is put.

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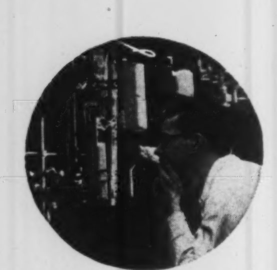

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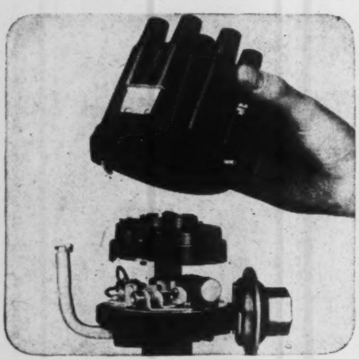

ELECTRICAL. For automotive, radio, TV transformer, X-ray, switch, appliance, and other equipment parts requiring high dielectric strength, low dissipation factor, and high volume resistivity. Like all Durez phenolics, their desirable properties include light weight and lustrous molded-in finish.

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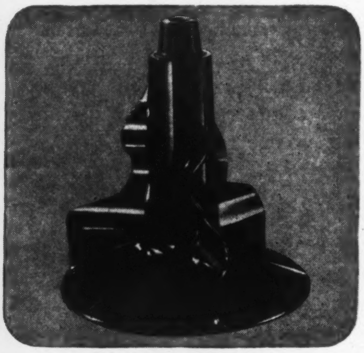

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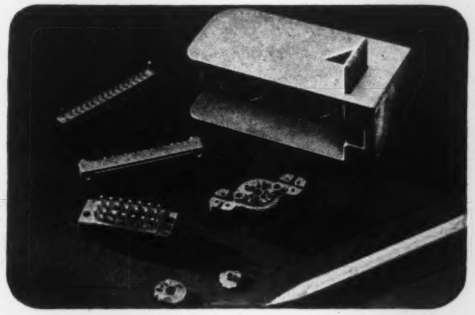

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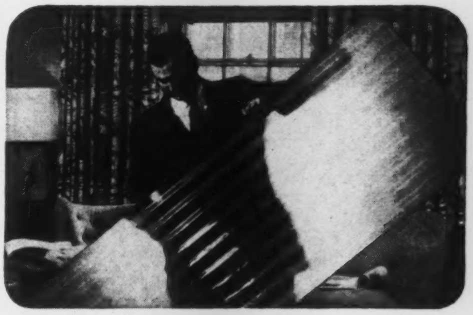

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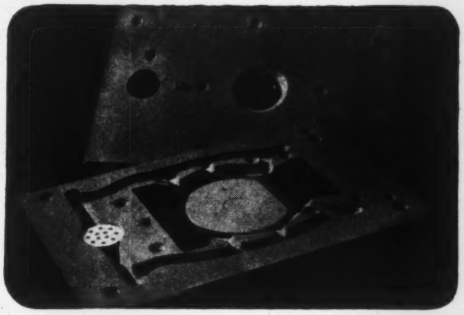

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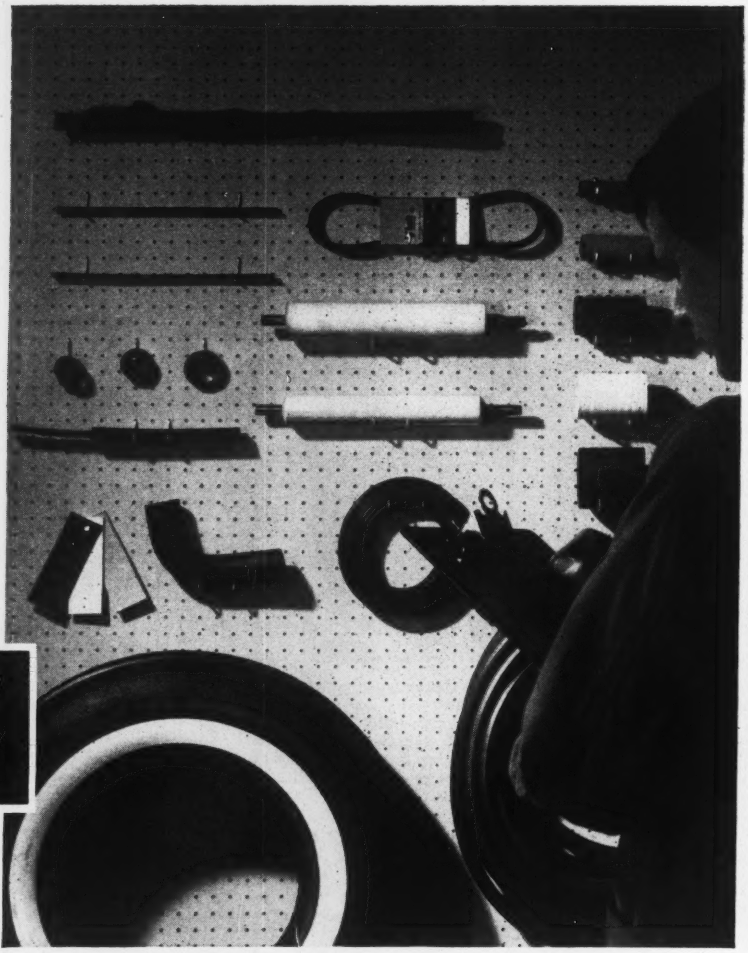

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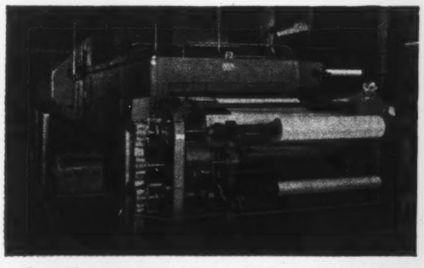

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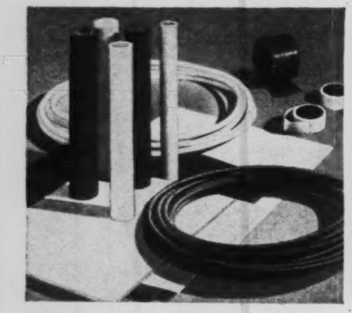

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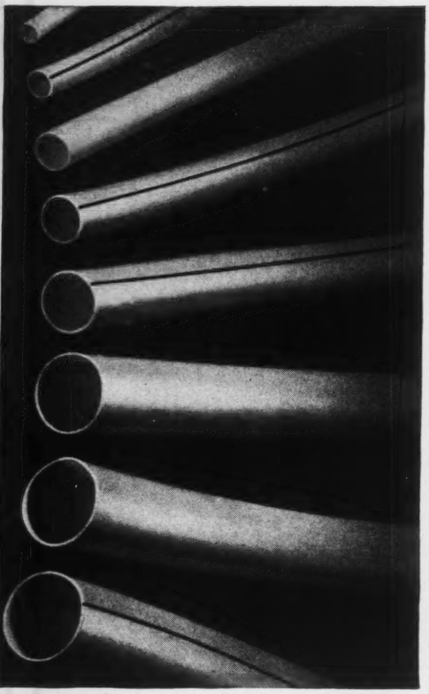

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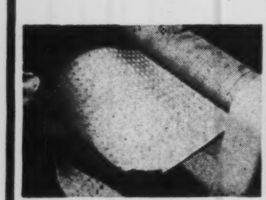

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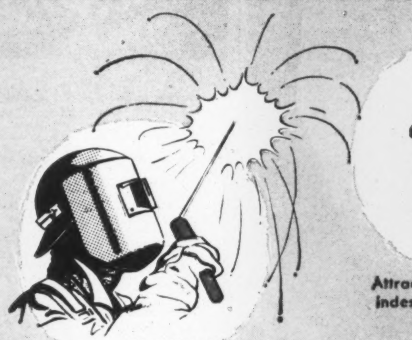
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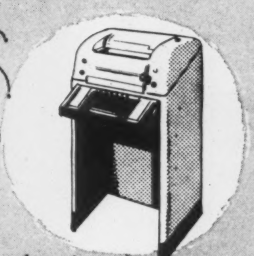
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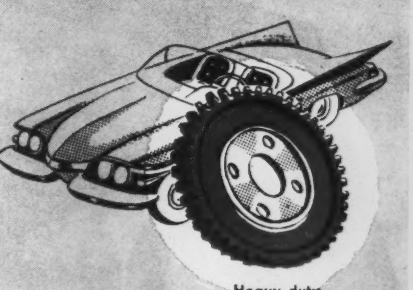
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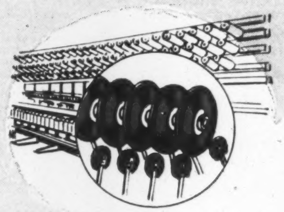
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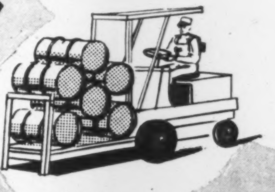
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☐ **TECHNICAL EDITING** *edited by B. H. Weil.* Here are the basic concepts and operating practices of internal communications, journal editing, book publishing, and graphic aids presentation for all technical fields. The contributors are leading authorities and they provide ideal guidance for both beginning and experienced editors. 1958, $5.75

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Joining — Heat sealing and non-heat sealing
Colors — Any color
Weight — 4 to 250 oz./sq. yd.
Widths — To 60 inches

Plants: Norwalk, Connecticut; Mobile, Alabama

CORDO

CHEMICAL CORPORATION

34 SMITH STREET
NORWALK, CONNECTICUT

CORDOPREG,® MOBALOY,® PREPREG

For high temperature and general purpose applications

Pre-Impregnated Fabrics
Roving & Chopped Roving Prepreg
Polyester
Epoxy
Phenolic
Silane
Phenyl Silane
Military Certified Resins and Reinforcements

Flexural Properties of Laminates, Cordopreg, Mobaloy at Elevated Temperatures

	Polyester	*Epoxy*	*Phenolic*	*Silane*	*Phenyl Silane*
160°	52,700 psi	48,000	—	—	—
500°	—	21,900	49,000	18,300	—
600°	—	—	—	—	41,000
700°	—	—	—	—	25,000

Plants: Norwalk, Connecticut; Mobile, Alabama

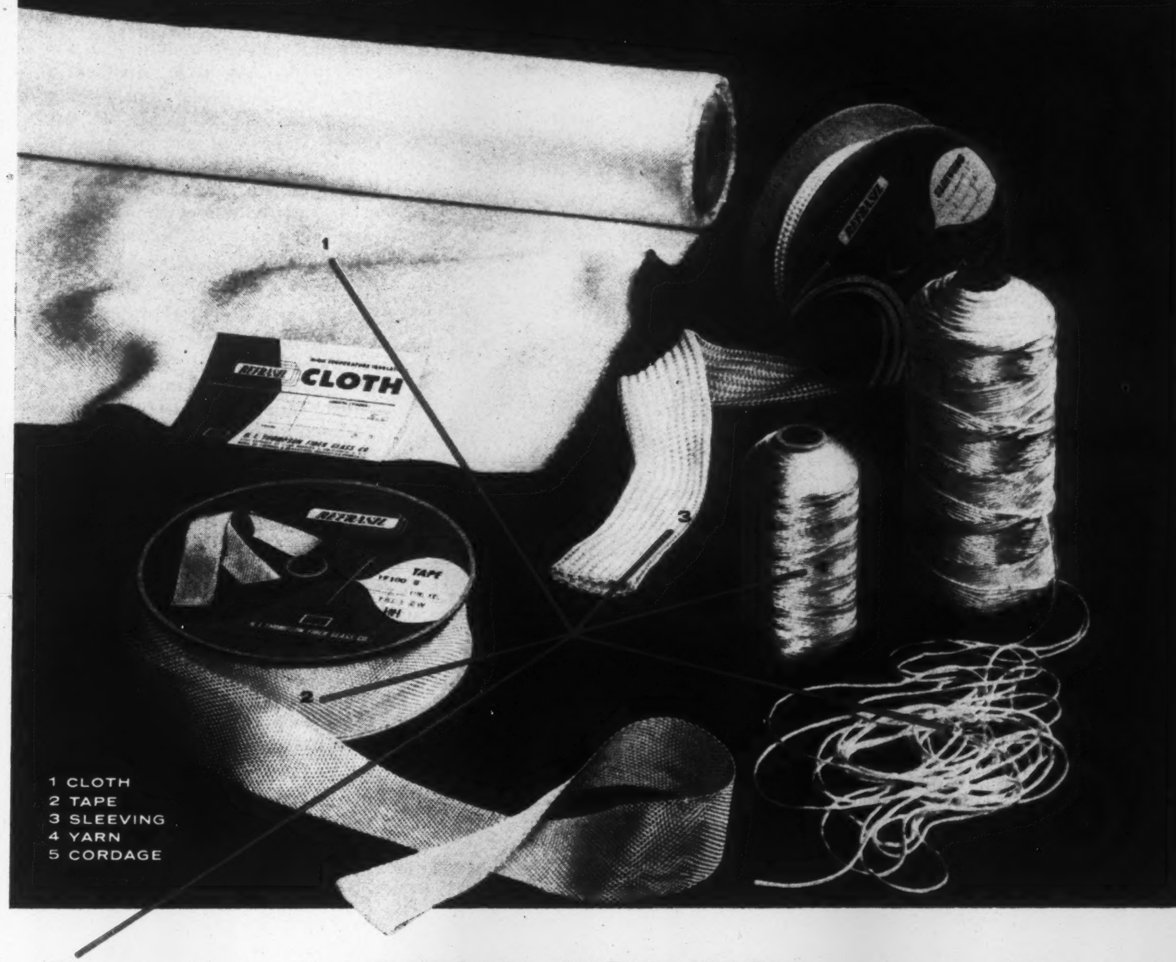
CORDO

MOLDING PRODUCTS, INC.

230 PARK AVENUE
NEW YORK 17, NEW YORK

For more information, turn to Reader Service card, circle No. 634

Insulate to 2000° F. with REFRASIL



This may be the SPECIAL INSULATION you're looking for!

REFRASIL PHYSICAL PROPERTIES:

- Chemical resistance of pure silica
- Resists temperatures up to 3000° F. under certain conditions
- Low Thermal conductivity
- Fiber diameter .00020-.00040 in.
- Specific heat .19 (Batt)
- Thickness .14-.15 in. (Batt)
- Surface density .05 lb./sq. ft. (Batt)

REFRASIL USES:

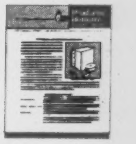
- 2000° F. continuous high temp. insulation
- Filtration of corrosive materials
- Removable, insulating blankets
- REFRASIL Reinforced Plastics (ASTROLITE for up to 15,000° for short duration)
- Thermocouple wire insulation
- Electric muffle furnaces
- Laboratory heating mantles

If you're looking for an efficient, lightweight 2000°-3000°F. insulating material in any of the physical forms shown above, REFRASIL may be your best answer.

Long proven for jet aircraft and missile use, REFRASIL is fast becoming an important industrial insulation for −300°F. cold to +3000°F. heat.

When other insulation materials fail in critical high temperature use, write or call for test samples of REFRASIL. It may be the *special* insulation you're looking for!

- *Write for REFRASIL Product Bulletin and Price List.*



HITCO

H. I. THOMPSON FIBER GLASS CO.
1733 Cordova Street, Los Angeles 7, Calif. • REpublic 3-9161

WRITE OR CALL YOUR NEAREST HITCO REPRESENTATIVE: EASTERN: Tom Kimberly, 38 Crescent Circle, Cheshire, Conn., BR. 2-6544; Fred W. Muhlenfeld, 6659 Loch Hill Rd., Baltimore 12, Md., VA. 5-3135 • **MIDWEST:** Burnie Weddle, 3219 W. 29th St., Indianapolis 22, Ind., WA. 5-8685 • **SOUTHWEST:** Marshall Morris, 2850A W. Berry, Rm. 7, Fort Worth, Tex., WA. 4-8679 **NORTHWEST:** J. L. Larsen, 5757 Oaklawn Pl., Seattle, Wash., PA. 5-9311 • **CANADIAN PLANT:** THE H. I. THOMPSON CO. OF CANADA LTD., 60 Johnston St., Guelph, Ont., TA. 2-6630

For more information, turn to Reader Service card, circle No. 583

A NEW HERCULES PLASTIC!

TYPICAL PROPERTIES OF HI-FAX

Crystalline melting point, °F.	268
Specific gravity	0.945-0.947
Mold shrinkage, in./in.	0.022-0.028
Water absorption, %	0.03
Heat-distortion temperature (66 p.s.i.), °F.	144-154
Deformation under 2000-lb. load for 6 hr. at 122°F., %	9-16
Hardness, Rockwell R	35-40
Impact, Izod, ft.-lbs./in., notched	1.5-12
unnotched	>32
Tensile yield stress at 73°F., p.s.i.	3450-4500
at 212°F.	1300-1800
Ultimate elongation at 73°F.,%	100-700
Dielectric constant	2.33
Power factor	0.0007

hi-fax°

First of the new Hercules family of plastics, Hi-fax is the Hercules trademark for high-density polyethylene. As produced by an exclusive process, it is superior in many ways to other high-density materials. As a result, Hi-fax offers important advantages to producers in the markets where it now serves. Its superior properties, combined with the outstanding processing economies it affords, yield quality, low-cost products.

Blown containers: Hi-fax is now the standard material by which all plastics used in blown bottles and containers are judged. It provides outstanding performance and economy, especially in products designed to package corrosive materials, offering a high degree of stress-crack resistance coupled with lightweight strength in thin-wall sections.

Industrial shapes: Excellent processability, outstanding low temperature resistance, dimensional stability, and durability in long-term use are characteristic of the many industrial parts now being fabricated with Hi-fax by extrusion and injection molding.

Wire: Wire and cable coatings made with Hi-fax provide a toughness and resistance to abrasion superior to almost any other plastic or rubber.

Pipe: A special pipe grade of Hi-fax yields a low-cost, thin-wall flexible pipe, NSF approved, and setting new standards for quality in flexible piping. Extruders have found it offers many processing advantages over competitive materials.

Flexible Pipe

Wire and Cable Coatings

Containers

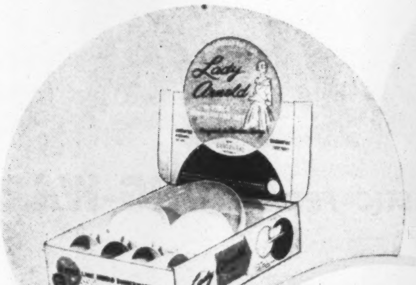
AVON
Deepclean
moisturized
cleansing
cream

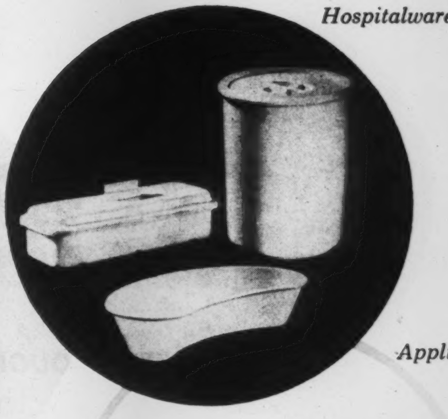
Cosmetic Packaging

Detergent Bottles

Want to know more about Hercules' NEW PLASTIC
For complete property and use data, or specific informati
on any of the products shown here, call or write:

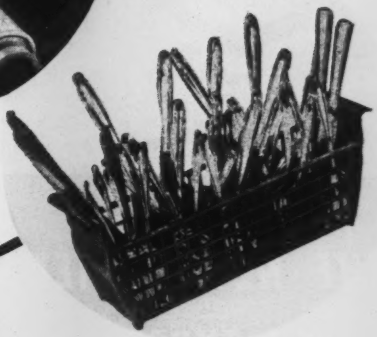
ANOTHER NEW HERCULES PLASTIC!





Appliances

Housewares



Pro-fax, the bright new name in thermoplastics, is the Hercules trademark for polypropylene. With a high softening point, Pro-fax is dimensionally stable at temperatures as high as 300°F. It has a hard, glossy surface finish, and is available in a full range of opaque and translucent colors. With a specific gravity of only 0.9, *Pro-fax is the lightest of all plastics*, providing a production bonus of many extra parts per pound over other materials in its same price-property class.

Pro-fax for injection molding: Pro-fax is an excellent general-purpose material now finding broad use in such markets as closures and containers, automotive and appliance parts, valves and fittings, housewares, toys, and sporting goods. Pro-fax molds rapidly and well, has only half the shrinkage of high-density polyethylene.

Pro-fax for extrusion: Pro-fax monofilaments are now in growing use in rope, fish nets, seat cover fabrics, outdoor furniture webbing, bristles, pen tubes, and a variety of industrial parts. Extruded Pro-fax sheet provides a splendid structural material for vacuum-forming, thermoforming, and fabrication. Pro-fax film for packaging has sparkling clarity, outstanding toughness, and excellent resistance to permeation.

pro-fax°

TYPICAL PROPERTIES OF PRO-FAX

Crystalline melting point, °F.	333
Specific gravity	0.901
Mold shrinkage, in./in.	0.015 to 0.020
Water absorption, %	0.03
Heat-distortion temperature (66 p.s.i.), °F.	221
Deformation under 2000-lb. load for 6 hr. at 122°F., %	2.0
Hardness, Rockwell R	93
Impact, Izod, ft.-lbs./in., notched	1
unnotched	>17
Tensile yield stress at 73°F., p.s.i.	4970
at 212°F.	1720
Ultimate elongation at 73°F., %	>220
Dielectric constant	2.0
Power factor	0.0003

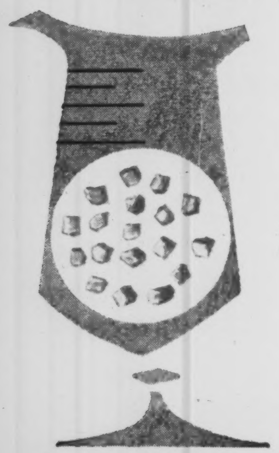
CP 59-10

HERCULES POWDER COMPANY
INCORPORATED
WILMINGTON 99, DELAWARE

For more information, turn to Reader Service card, circle No. 578

CYCOLAC

THE TOUGH, HARD **ABS** PLASTIC FROM **BORG-WARN**



Cycolac's unique combination of properties gives you unlimited freedom in product design coupled with new economy and speed in production! You get outstanding strength and rigidity without increasing wall thickness—you get corrosion, stain and temperature resistance—less overall weight—sparkling colors and hard, glossy surface. With Cycolac, you can simplify basic construction, take advantage of molded contours, forms and shapes unobtainable or too costly in other materials. And you get every advantage, every economy of high-speed injection molding or vacuum forming.

For more information, circle No. 500

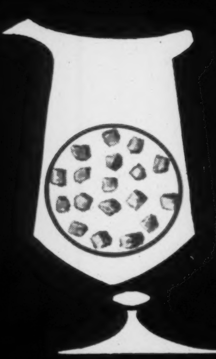
CYCOLAC®

THE NEW DIMENSION IN DESIGN...THE NEW ELEMENT

4 TYPES OFFER YOU THE GREATEST ARRAY OF DESIRABLE PROPERTIES

CYCOLAC H

Superior impact-strength over wide-temperature range; maximum impact-resistance of the molding grades. Suitable for high-impact extruded sheet.



CYCOLAC C

For use in high tensile pipe, profile and miscellaneous extrusions requiring superior, high-temperature performance.

CYCOLAC L

Extruded pipe and tubing; intricate profile extrusions; calendered sheet.

CYCOLAC T

For maximum toughnes high hardness and ten strength. Superior flow injection molding of appe ance parts.

PACESETTER IN

Marbon CHEMICAL

SYNTHETIC RESINS

Division of BORG-WARNER • Washington, W. Va.

also represented by

WEST COAST: Harwick Standard Chemical Co., Los Angeles, Cal.
CANADA: Dillons Chemical Co. Ltd., Montreal & Toronto
EXPORT: British Anchor Chemical Corp., New York

etter
n
nore ways
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ODUCTION!

CHEMICAL

CYCOLAC resins are almost completely resistant to aqueous acids, alkalies and salts. Concentrated sulfuric and nitric acids produce disintegration but concentrated phosphoric and hydrochloric acids have little effect. Low KB solvents, alcohols, and animal, vegetable and mineral oils produce insignificant changes.

Glacial acetic acid, carbon tetrachloride, aromatic hydrocarbons and high KB solvents cause marked swelling. Esters, ketones, and ethylene dichloride are solvents for **CYCOLAC**.

(ASTM D543-56T IMMERSION TEST)

PROPERTIES OF CYCOLAC RESINS

PROPERTY	TYPE OF RESIN				TEST METHOD
MECHANICAL	**L**	**H**	**T**	**C**	**ASTM**
				Black Only	
Tensile Strength[2] psi 160°F	3,300	3,300	4,500	5,500	D638-58T
73°F	5,100	5,100	6,400	7,800	
−40°F	7,800	7,800	9,400	11,500	
Tensile Modulus[2], psi 73°F	200,000	210,000	280,000	340,000	D638-58T
Flexural Strength[1] 160°F, 73°F, −40°F	No failure	No failure	No failure	No failure	D790-58T
Flexural Yield Strength[1], psi 160°F	4,300	4,100	5,900	6,800	
73°F	6,800	6,800	9,400	10,800	D790-58T
−40°F	10,500	10,500	13,800	16,000	
Flexural Modulus[1], psi 160°F	160,000	170,000	230,000	270,000	D790-58T
73°F	210,000	220,000	280,000	340,000	
−40°F	250,000	250,000	320,000	400,000	
Hardness[1]	R86	R87	R101	R108	Rockwell
			M10	M35	D785-51
Specific Gravity[1]	1.02	1.02	1.04	1.06	—
IMPACT STRENGTH	**L**	**H**	**T**	**C**	**ASTM**
				Black Only	
Impact Strength[2],	⅛″ bar	⅛″ bar	⅛″ bar	⅛″ bar	D256-56
(Izod specimens, ft.-lb.)					Method A
Un-notched 73°F	38.0	34.0	30.0	29.0	
Notched 73°F	6-8	5-7	3-5	4-5	
−20°F	3.0	2.0	1.4	0.9	
−40°F	2.0	1.5	1.0	0.7	
Impact Strength[1],	¼″ bar	¼″ bar	¼″ bar	¼″ bar	D256-56
(Charpy specimens, ft.-lb.)					Method B
Un-notched 73°F	>40	>40	26.5	>40	
Notched 73°F	6.2	4.9	3.4	3.4	
−20°F	3.2	2.3	1.6	1.3	
−40°F	2.7	2.0	1.5	1.0	
THERMAL	**L**	**H**	**T**	**C**	**ASTM**
				Black Only	
Heat Distortion Point[1], °F, 264 psi	196	196	198	215	D648-56
½″x½″x5″ bar 66 psi	208	208	212	227	
(unannealed) Zero Load	223	220	220	238	
Heat Distortion Point[1], °F, 264 psi	224	220	219	232	
½″x½″x5″ bar 66 psi	230	225	224	236	
(annealed) Zero Load	241	231	229	244	
Coefficient of Linear Thermal Expansion[1], in/in/°C	$10.1\text{x}10^{-5}$	$10.4\text{x}10^{-5}$	$8.9\text{x}10^{-5}$	$7.8\text{x}10^{-5}$	D696-44
Thermal Conductivity[1]					C177-45
Btu/hr/ft²/°F/in	1.46	1.46	1.54	1.80	
Cal/sec/cm²/°C/cm	$5.05\text{x}10^{-4}$	$5.05\text{x}10^{-4}$	$5.30\text{x}10^{-4}$	$6.20\text{x}10^{-4}$	
Flammability[1], in/min.	3.47	3.47	3.53	2.75	D635-56T
Deformation under load[1], % 24 hr/122°F/2000 psi	1.35	1.38	0.81	0.41	D621-51
Mold Shrinkage[2], %	0.5	0.5	0.5	0.5	D955-51
ELECTRICAL	**L**	**H**	**T**	**C**	**ASTM**
				Black Only	
Dielectric Constant[1]					D150-54T
60 cycles	2.86	2.87	2.91	3.24	
10^3 cycles	2.85	2.86	2.91	3.21	
10^6 cycles	2.77	2.76	2.44	3.11	
Power Factor[1]					
60 cycles	.005	.005	.005	.005	D150-54T
10^3 cycles	.006	.006	.006	.006	
10^6 cycles	.008	.009	.008	.012	
Volume Resistivity[1], ohm-cm	$>3.92\text{x}10^{16}$	$>3.80\text{x}10^{16}$	$>3.96\text{x}10^{16}$	$>3.57\text{x}10^{16}$	D257-58
Arc Resistance[1], Sec	71	71	82	87	D495-58T

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* [1] Compression Molded
[2] Injection Molded

The results given are based upon tests which we believe to be reliable. Due to varying conditions and methods of processing, we cannot guarantee results to be obtained. Nothing contained in this brochure is intended as a recommendation to use our products so as to infringe on any patents.

SUPPLIERS' LITERATURE

Nonmetallics
(except Plastics and Rubber)

Orion, Dacron Felts. American Felt Co., 4 pp, illus. Dimensional and thermal stability, chemical resistance and breaking strength of Orion and Dacron felts. **164**

Properties of Ceramics. American Lava Corp., Steatite Div., 8 pp, No. 591. Physical, mechanical and electrical properties of steatite, forsterite, cordierite, lava, alumina and magnesium silicate ceramics. Also gives properties of silicon carbide and zirconium oxide. **165**

Locking Sealant for Metal Parts. American Sealants Co., 6 pp. illus. Properties, uses and application data for a liquid locking sealant called Locktite for use on metal parts. **166**

Beryllium Oxide. Beryllium Corp., 8 pp, illus. Physical and mechanical properties and uses of beryllium oxide products. **167**

Boron Nitride. Carborundum Co., Refractories Div., 4 pp, illus. Electrical properties, uses, corrosion resistance, chemical composition and thermal shock resistance of a machinable boron nitride. **168**

Nonmetallic Materials. Carborundum Co., 12 pp, illus. "Advanced Materials Technology" gives information on properties and uses of nonmetallic materials. **169**

Flocked Paper. Cellusuede Products, Inc., illus. Sample kit containing actual swatches of colored flocked paper. Suggestions for cutting, folding and printing the flocked paper. **170**

Kraft Paper. Cincinnati Industries, Inc., 8 pp. Characteristics and uses of cross-creped stretchable kraft paper. **171**

Glass Fabrics. Coast Mfg. & Supply Co., 20 pp, illus. Properties and uses of plain, finished and impregnated glass fabrics. **172**

Felt. Continental Felt Co. Information on wool, synthetic fiber and colored felts. **173**

Alumina Ceramics. Coors Porcelain Co., 4 pp, illus., No. 858. Mechanical and electrical properties, dimensional data and design information for high strength alumina ceramics for use in rockets and missiles. **174**

Coated Fabrics. Cordo Chemical Corp., 5 pp. Properties, uses and prices for a line of lead powder-filled vinyl-coated cotton duck and glass fabrics. **175**

Industrial Glassware. Corning Glass Works, Technical Products Div., 8 pp, illus., No. B-91. Physical properties, transmittance characteristics and uses of industrial glassware. **176**

Coated Fabrics. E. I. du Pont de Nemours & Co., Inc., Fabrics Div., 16 pp, illus. Physical, mechanical and electrical properties, chemical resistance and uses of elastomer-coated fabrics. **177**

Thermal Insulation. Dyna-Therm Chemical Corp., 4 pp. illus. Information on a mastic-type chemical coating designed as a high heat insulating material and an erosion and corrosion resistant coating. **178**

Fused Silica. Amersil Quartz Co., Div. of Engelhard Industries, Inc., 4 pp, illus. Physical characteristics, uses, electrical properties, heat resistance and sizes of fused silica tubing, pipe, crucibles and storage vessels. **179**

Resin-Impregnated Felt. Felters Co., 4 pp, illus. Properties and uses for a thermoplastic resin-impregnated felt that can be electronically stitched and heat sealed. **180**

Friction Materials. World Bestos Div., Firestone Tire & Rubber Co., 4 pp, illus. Briefly describes heat resistance and service life of the company's brake linings. **181**

Wood Products. Gamble Brothers, Inc., 28 pp. illus. Shows wood products manufactured by the company, including industrial wood parts, chair parts and athletic apparatus. **182**

Synthetic Sapphires. Aurele M. Gatti Inc., 4 pp, No. 4. Properties and availability of synthetic sapphire rods, cylinders, balls and special parts. **183**

Electrical Insulating Materials. General Electric Co., Insulating Materials Dept., 12 pp, illus. No. GET-2929. Properties and uses of such electrical insulating materials as mica mat, varnished cloths and papers, insulating varnishes, wire enamels, irradiated polyethylene, insulating finishes and adhesives. **184**

Nylon Coated Fabrics. General Tire & Rubber Co., Textileather Div., 6 pp, illus. Discusses properties and uses of nylon coated fabrics. **185**

Ceramics. Centralab, Div. of Globe-Union Inc., 16 pp, illus. Mechanical, electrical and environmental characteristics of ceramics. Information on the advantages and disadvantages of various ceramic fabricating techniques. **186**

Graphite. Graphite Specialties Corp., 4 pp, No. GS-101-1. Chemical and physical properties of an impervious graphite for high temperature parts. **187**

Glass Fiber Insulation. L. O. F. Glass Fibers Co., Div. of Johns-Manville Corp., 4 pp. illus. Insulation efficiency, uses, vibration and airflow resistance, compressibility, dimensional data and tensile strength of quartz and glass fiber thermal insulations. **188**

Cemented Carbides. Kennametal Inc., 24 pp, illus., No. B-111-A. Design data, physical and mechanical properties, corrosion resistance and uses of cemented carbides. **189**

Specialty Papers. Knowlton Bros., Inc., 12 pp, illus. Information on technical and industrial specialty papers. Shows company research, manufacturing and quality control facilities. **190**

Specialty Glass Products. Kopp Glass, Inc., 20 pp, illus., No. 553-A. Information on such specialty glass products as lenses, filters, warning beacons, aircraft panel lights, sight glasses and instrument cases. **191**

Glass Products. Lancaster Glass Corp., 28 pp, illus. Case histories on the use of glass in television tubes, auto dome lights, desk sets, refrigerator lights and vending machines. **192**

Lithium Products. Lithium Corp. of America, Inc., 4 pp. Properties and uses of lithium metal derivatives and special lithium ceramic compounds. **193**

Industrial Ceramics. McDanel Refractory Porcelain Co., 4 pp, No. D358. Physical properties, design information and fabricating data for alumina, porcelain and zirconia ceramics. **194**

Metal-Wood Laminate. Met-L-Wood Corp., 16 pp, illus., No. 522. Lists woods and metals used in making Met-L-Wood laminates and compares stiffness and weight of the laminate with properties of oak, steel and aluminum. **195**

Mica Insulation. Mica Insulator Div., Minnesota Mining & Mfg. Co., 20 pp, illus. Thicknesses and dielectric strengths of mica rings, tubes and tapes for electrical insulations. **196**

Paper Products. Mosinee Paper Mills Co., 3 pp, illus. Outlines uses and advantages of a flame resistant paper, and average physical properties of flat and creped neutral papers. **197**

Glass-Bonded Mica. Mycalex Corp. of America, 24 pp, illus. Physical, electrical and thermal properties, and dimensional tolerances of ceramo-plastics and glass-bonded micas. **198**

Refractory Materials. Norton Co., Electro-Chemical Div., 16 pp. illus. Properties, uses and sizes of silicon carbide, zirconium oxide, calcium zirconate and boron carbide refractory materials. **199**

Silica Foam Insulation. Pittsburgh Corning Corp., 4 pp, illus., No. FS-1. Physical properties, uses, installation data, heat resistance, and shapes and sizes of a silica foam insulation. **200**

Glass Fiber Insulation. Pittsburgh Plate Glass Co., Fiber Glass Div., 4 pp. illus. Advantages of using glass fibers for sound and heat insulation applications. **201**

Carbon Graphite. Pure Carbon Co., Inc., 12 pp, illus., No. 55. Catalog on carbon graphite for mechanical applications. **202**

Coated Fabrics. Reeves Bros., Inc., 4 pp, illus., No. 107B. Physical properties, dimensions and uses of a neoprene rubber-coated nylon fabric. **203**

Carbon, Graphite. Speer Carbon Co., 8 pp, No. 7/57-AD. Information on carbon and graphite for high temperature applications. Also sizes of carbon and graphite products. **204**

Piezoelectric Ceramics. Sprague Electric Co., 2 pp, illus., No. 6900. Properties and uses of piezoelectric ceramics. **205**

Industrial Ceramics. Star Porcelain Co., 20 pp, illus., No. 57. Data on commercial white porcelain, Nu-blac, Thermolain, Steatite, Vitrolain, Humidolain, Lavolain and 5606 Refractory materials. **206**

Ceramic Permanent Magnets. D. M. Steward Mfg. Co., 4 pp, illus. Electrical properties, shapes, tolerances, advantages and uses of ceramic permanent magnets. **207**

Synthetic Fiber Felts. Troy Blanket Mills, Industrial Div., 8 pp, illus. Strength, dimensional stability, wear, moisture and chemical resistance, and uses of a non-woven synthetic fiber felt made of Dacron, Orlon and other synthetic fibers. **208**

Nuclear Graphite. National Carbon Co., Div. of Union Carbide Corp., 8 pp, illus., No. S-4905 MH. Properties and advantages of graphite for use as shields, control rods, fuel elements, thermal columns, moderators and reflectors in nuclear reactors. **209**

Acylic Fiber. Union Carbide Chemicals Div., Textile Fibers Dept., Union Carbide Corp., 16 pp, illus. How "Dynel" acrylic fiber is made. Outlines its properties and uses in industrial fabrics. **210**

Sintered Metallic Oxides. U. S. Stoneware Co., Alite Div., 8 pp, illus., No. A-7R. Electrical characteristics, size limitations, dimensional tolerances, chemical and heat resistance, and physical properties for a series of sintered metallic oxides called Alite. **211**

Treated Felts. Western Felt Works, Treated Felts Section. Properties and uses of felts treated with TFE, polyester and polyethylene resins. Contains samples. **212**

Insulating Materials. Westinghouse Electric Corp., Materials Mfg. Dept., illus., No. B-7206. Types, characteristics and applications of Class A shellac and varnish-coated papers and organic varnished glass. Also discusses Class H insulations. **213**

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PROPERTIES OF MATERIALS

Other Nonmetallics

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Mechanical and Electrical Ceramics—Fired Parts

Type ➡	Polycrystalline Glass (Pyroceram) 9606[b]	Polycrystalline Glass (Pyroceram) 9608[b]	Cordierite	Forsterite
PHYSICAL PROPERTIES				
Specific Gravity	2.60	2.50	2.29–2.65	2.9
Ther Cond, Btu/hr/sq ft/°F/ft	2.10	1.14	0.97–2.40	1.94–2.40
Coef of Ther Exp, per °F				
68–212 F	3.16×10^{-6}	$0.39\text{–}1.1 \times 10^{-6}$[c]	2.08×10^{-6}	4.72×10^{-6}
68–932 F	—	—	1.68×10^{-6}	5.40×10^{-6}
Thermal Shock Resistance	Good	Good	Good	Moderate
Water Absorption, %	0.00	0.00	0.02–3.2	0.00–0.02
Gas Permeability	Gas-tight	Gas-tight	—	Gas-tight
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	17.3×10^{6}	12.5×10^{6}	7×10^{6}	—
Mod of Rupture, 1000 psi	20	16–23	6.8	19
Tensile Strength, 1000 psi	—	—	3.0	10
Hardness (Knoop)	698[d]	703[d]	7	7.5
Impact Strength (Charpy), in. lb				
¾ In. Dia	—	—	7.4	7.5
½ In. Dia	—	—	4.4	2.4–4.0
Flexural Strength, 1000 psi	—	—	15	20
Compressive Strength, 1000 psi	—	—	52–95	80–85
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm				
68–77 F	—	—	$>10^{14}$	$>10^{14}$
212 F	—	—	—	5.0×10^{13}
482 F	10^{10}	1.26×10^{8}	—	—
572 F	—	—	—	7.0×10^{11}
662 F	4×10^{8}	6.31×10^{6}	—	—
932 F	—	—	—	1.2×10^{10}
1292 F	—	—	—	1.0×10^{8}
1652 F	—	—	—	3.0×10^{6}
Dielectric Strength, v/mil	—	—	140–230	250
Dielectric Constant				
60 Cycles	—	—	—	6.3
1 Mc	5.58	6.78	4.02–6.23	6.2–6.5
100 Mc	—	—	—	6.1
10,000 Mc	5.45	—	—	5.8
Dissipation Factor				
60 Cycles	—	—	—	0.0014
1 Mc	0.0015	0.0030	0.0010–0.00930	0.0002–0.0004
100 Mc	—	—	—	0.0003
10,000 Mc	0.00033	—	—	0.0010
Loss Factor				
60 Cycles	—	—	—	0.009
1 Mc	0.009	—	0.0297–0.0579	0.001–0.002
100 Mc	—	—	—	0.002
10,000 Mc	0.002	—	—	0.0058
Te Value, F[e]	—	—	1436	680->1832
Temp Coef of Capacitance Chg[f]	—	—	420	—
HEAT RESISTANCE				
Max Rec Svc Temp, F	—	—	—	1832
Softening Temp, F	1250	1250	—	—
USES	Developed for uniform electrical properties in missile radomes. Other uses: electronic equip., abrasive binder, bearing parts, structural parts in hypersonic aircraft, air compressor blades	General purpose; laboratory equip., pump parts, pipe caps, thread guides, replacement for steel bearings, heat exchange tubes (under test), brake shoes, aircraft structural parts	Aircraft firewall connectors, appliance coil supports and terminal blocks, automotive heater cores, hot point insulators, brazing fixture parts, foundry parts, fuel burner tips, thermostat controls	Very low loss insulators, ceramic-to-metal seals (close tolerances obtainable by grinding)

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[a] Alumina properties are on "Refractories" pages. [b] Manufacturer's designations for opaque grades; transparent grades are available.
[c] 77–572 F. [d] Knoop hardness at 100 gm.
[e] Te value is the temperature at which a cubic centimeter of the material has a resistance of 1 megohm. [f] 77–185 F, parts per million.

Mechanical and Electrical Ceramics—Fired Parts

Type ➡	Standard Electrical	Steatite	Zircon
PHYSICAL PROPERTIES			
Specific Gravity	2.37–2.53	2.5–2.92	3.43–3.86
Ther Cond, Btu/hr/sq ft/°F/ft	0.87–1.57	1.45–1.94	2.88–3.61
Coef of Ther Exp, per °F			
68–212 F	2.00 x 10^{-6}	3.33–3.99 x 10^{-6}	1.31–1.84 x 10^{-6}
68–932 F	2.70 x 10^{-6}	4.52–5.50 x 10^{-6}	2.09–2.16 x 10^{-6}
Thermal Shock Resistance	Fair	Moderate	Good
Water Absorption, %	0.0–0.1	0.0–1.0	0.0–9.0
Gas Permeability	Gas-tight	—	—
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	10 x 10^6	13–16 x 10^6	21 x 10^6
Mod of Rupture, 1000 psi	11	19–22	9–24
Tensile Strength, 1000 psi	2.5–7.0	4.8–15	4.5–12
Hardness (Mohs)	7.0–7.5	7.5	8
Impact Strength (Charpy), in.-lb			
¾ In. Dia	8.2	10.5–14.0	8.9–11.4
½ In. Dia	—	3.8–5.0	5.50–5.64
Flexural Strength, 1000 psi	5.4–12.0	11–20	18.5–22.0
Compressive Strength, 1000 psi	49.1–70.0	66–90	60–100
Transverse Strength, 1000 psi	11	—	—
ELECTRICAL PROPERTIES			
Volume Resistivity, ohm-cm			
68–77 F	10^{13}–10^{15}	>10^{14}	>10^{14}
212 F	1.2 x 10^8[c]	0.21–>100 x 10^{13}	2.0 x 10^{13}
570 F	5.0 x 10^6	0.6–800 x 10^8	5.5 x 10^{11}
930 F	4.0 x 10^5[d]	0.32–300 x 10^6	5.5 x 10^8
1290 F	—	2.3–500 x 10^6	1.4 x 10^7
1650 F	—	7.0–680 x 10^3	8.2 x 10^5
Dielectric Strength, v/mil	55–300	145–280	60–290
Dielectric Constant			
60 Cycles	5.4–7.0	5.9–6.3	9.1
1 Mc	—	5.5–6.51	5.30–9.20
100 Mc	—	5.6–6.0	8.6
10,000 Mc	—	5.3–5.8	8.4
Dissipation Factor			
60 Cycles	0.0090–0.0112	0.0013–0.0150	0.0360
1 Mc	—	0.0011–0.0075	0.0007–0.0022
100 Mc	—	0.0009–0.0028	0.0012
10,000 Mc	—	0.0014–0.0054	0.0027
Loss Factor			
60 Cycles	0.053–0.060	0.008–0.090	0.327
1 Mc	—	0.007–0.0252	0.0041–0.0135
100 Mc	—	0.005–0.016	0.010
10,000 Mc	—	0.008–0.030	0.023
Te Value, F[a]	680–842	824–1544	1292–1598
Temp Coef of Capacitance Chg[b]	630	120	175
HEAT RESISTANCE			
Max Rec Svc Temp, F	1820	1832	2012
USES	Low voltage insulators, vitrified high voltage insulators, wire supports, outlet boxes, lightning arrestors, suspension insulators, x-ray rods and tubes	Aircraft insulators, appliance housings, electric line insulators, tube sockets, electrical instrument spacers and feed-through bushings, fuel igniters, camera and projector rollers, thermostat controls	Aircraft firewall connector plugs and glow plugs; electronic tube sockets, coil forms, spacers, brackets, printed circuits and plates; pump valves, plungers and seats

[a] Te value is the temperature at which a cubic centimeter of the material has a resistance of 1 megohm.
[b] 77-186 F, parts per million. [c] 392 F [d] 752 F

Mica—Sheet, Molded

Type ➡	Natural Muscovite	Synthetic Fluor-Phlogopite	Glass-Bonded Synthetic[a]	
			Insulation	Capacitor
PHYSICAL PROPERTIES				
Specific Gravity	2.6–3.2	2.9	3.0, 2.6–3.8	3.25, 3.5–3.8
Ther Cond, Btu/hr/sq ft/°F/ft	0.25–0.36	0.3–0.4	0.29, 0.23–0.31	—
Coef of Ther Exp, per °F	1.8×10^{-5}	$1.44\text{–}2.70 \times 10^{-5}$	$1.8, 1.8\text{–}2.0 \times 10^{-5}$	$1.8, 1.8\text{–}2.0 \times 10^{-5}$
Spec Ht, Btu/lb/°F	0.20	0.25	0.16, 0.13–0.24	—
Water Absorption	Low	Low	Nil	Nil
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$20\text{–}30 \times 10^{6}$	25×10^{6}	$9\text{–}12, 7\text{–}8 \times 10^{6}$	$9\text{–}12, 7\text{–}8 \times 10^{6}$
Ten Str, 1000 psi	40–50	45–55	6–7, 5–6	6, 5
Hardness				
Knoop	90	200	M110–120,[b] M115–130[b]	—
Mohs	3–4	3.4	—	—
Impact Str (Izod notched), ft-lb/in.	—	—	1.8, 0.7	—
Flex Str, 1000 psi	—	—	15–18, 10–15	12–15, 10–15
Compr Str, 1000 psi	>150	>150	35–42, 20–25	35–42, 20–25
ELECTRICAL PROPERTIES				
Vol Res, ohm-cm	$10^{13}\text{–}10^{17}$	$10^{13}\text{–}10^{17}$	$10^{14}\text{–}10^{15}, 10^{14}\text{–}10^{17}$	$10^{14}, 10^{14}$
Dielec Str (step by step, ¼ in.), v/mil	1000–2000	1000–2000	400–600, 400–500	270–400, 300–400
Dielec Const				
60 Cycles	5.4–8.7	6.5	7.5–7.6, 7.0–9.5	—
10^{6} Cycles	5.4–8.7	6.5	7.4–7.9, 6.9–9.2	10–25, 10–40
Dissip Factor				
60 Cycles	0.0025	0.002–0.004	0.0035–0.0070, 0.007–0.050	0.0020–0.0040, 0.0025
10^{6} Cycles	0.0001–0.0004	0.0001–0.0003	0.0015–0.0020, 0.0015–0.0120	0.0035
Arc Resistance, sec	High	High	300, 250	300, 250
FABRICATING PROPERTIES				
Machinability	Fair, readily punched	Fair, punches more readily than Natural	Fair to good; poor	Fair to good; poor
Moldability	—	—	Fair; good	Fair; good
HEAT RESISTANCE				
Max Rec Svc Temp, F	1110	1400–1800	600–1000, 500–800	600–700, 500–600
Heat Dist Temp (264 psi), F	—	—	850, 700	800, 650
Ther Shock Res	—	—	Moderate	Moderate
CHEMICAL RESISTANCE	Good res to most chemicals and molten materials exc hydrofluoric acid. Oils generally cause delamination	Slightly better chemical res than Natural; high res to oils. High res to high pressure, high temp water	Good res to organic solvents; poor res to strong acids and alkalis	Good res to organic solvents; fair res to strong acids and alkalis
USES	Furnace peepholes, boiler gage glass; capacitors, tube spacers	Experimental high temp tube spacers and waveguide windows; used to make glass-bonded synthetic mica	Electromechanical devices, high temp (660–900 F) insulators requiring high stability (e.g., computer parts)	Stable capacitors, tuners; high temp uses

[a] The first value or range in each column refers to glass-bonded mica produced by compression molding, the second to transfer molding.

[b] Rockwell.

Refractory Ceramics and Cermets—Fired or Sintered Parts

HIGH ALUMINA CERAMICS[a]

Type (% alumina) →	85%	95%	99+%
PHYSICAL PROPERTIES			
Specific Gravity	3.45	3.65	3.85
Ther Cond (200 F), Btu/hr/sq ft/°F/ft	6.2	10.3	10.7
Coef of Ther Exp, per °F			
77–390 F	3.1 x 10^{-6}	3.7 x 10^{-6}	—
77–750 F	3.7 x 10^{-6}	4.0 x 10^{-6}	—
77–1100 F	3.9 x 10^{-6}	4.3 x 10^{-6}	4.3 x 10^{-6}
77–1470 F	4.1 x 10^{-6}	4.5 x 10^{-6}	—
77–1830 F	4.3 x 10^{-6}	4.7 x 10^{-6}	—
Water Absorption, %	0.0	0.0	0.0
Max Rec Svc Temp, F	2460	3000	3540
ELECTRICAL PROPERTIES			
Dielec Str, v/mil	200	250	300
Dielec Const (77 F, 1 mc)	8.2	8.9	9.6
Power Factor (77 F, 1 mc)	0.0009	0.00035	0.00027
Loss Factor (77 F, 1 mc)	0.007	0.003	0.003
Te Value, F	1560	1960	2012
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	32 x 10^6	40 x 10^6	50 x 10^6
Ten Str, 1000 psi	20	30	39
Flex Str, 1000 psi	41	45	47
Compr Str, 1000 psi	250	300	400
Hardness			
Mohs	9	9	9
Knoop	1450	1750	—
Impact Str (Charpy), in.-lb	6.5	7.0	—

[a] The values given are not maximum values and are dependent upon the minor components or fluxes used as well as a number of other factors.

ALUMINA CERMETS

Type →	Chromium-Alumina	Molybdenum-Chromium-Alumina[a]
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.21	0.22
Porosity, %	<0.25	<0.25
Melting Point (approx), F	3362	—
Ther Cond, Btu/hr/sq ft/°F/ft	29[a]	—
Coef of Ther Exp, per °F	4.7 x 10^{-6}[b]	5.2 x 10^{-6}[c]
Spec Ht (calc), Btu/lb/°F	0.16	0.14
Poisson's Ratio	0.22	0.25–0.27
MECHANICAL PROPERTIES		
Mod of Elast in Tension, 10^6 psi	41 x 10^6	37–39 x 10^6
Ult Ten Str, 1000 psi		
Rm Temp	21	—
800 F	20.5	—
1200 F	20	—
1500 F	19.7	—
1800 F	16.8	—
2000 F	11.7	—
Hardness (Rockwell)	C37	C45–55
Mod of Rupture, 1000 psi		
Rm Temp	45	55[d]
1800 F	27	55
2100 F	18	29
2400 F	4.6	12
Compr Str, 1000 psi	110	240
Mod of Rigidity, psi	17 x 10^6	15 x 10^6
Shear Str, 1000 psi	40	—
Bulk Modulus, psi	21 x 10^6	26 x 10^6

[a] At 500 F. [b] At 32–1832 F. [c] At 68–1472 F.

[d] Addition of tungsten raises room temperature modulus of rupture to about 70,000 psi.

REFRACTORY OXIDES

Type →	Beryllia (BeO)	Calcia (CaO)	Magnesia (MgO)	Thoria (ThO_2)	Zirconia (stabilized ZrO_2)	Silica (vitreous SiO_2)
Melting Point, F	4620	4710	5070	6000	4710	—
Ther Cond (at spec temp and porosity), Btu/hr/sq ft/°F/ft	9.52 (2190 F, 5–10%)	4.12 (1830 F, 9%)	1.47 (2190 F, 22%)	0.0 (2190 F, 17%)	0.53 (2190 F, 28%)	0.80 (0.9%)
Coef of Ther Exp, per °F	52.8 x 10^{-7} (68–2550 F)	75.5 x 10^{-7} (68–2190 F)	77.8 x 10^{-7} (68–2550 F)	52.8 x 10^{-7} (68–2550 F)	30.6 x 10^{-7}[a] (68–2190 F)	2.8 x 10^{-7} (68–2280 F)
Max Use Temp in Oxidizing Atm, F	4350	4350	4350	4890	4530	—
Hardness (Mohs)	9	4.5	6	7	7–8	—
Thermal Shock Resistance	Excellent	Fair	Fair	Poor	Fair	Excellent
Stability in —						
Reducing Atmosphere	Excellent	Poor	Poor	Good	Good	Fair
Carbon	Excellent	Poor	Good	Fair	Fair	Good
Acid Slags	—	Poor	Poor	Poor	Good	Good
Basic Slags	Fair	Fair	Good	Good	Poor	—
Metals	Good	Fair	Fair	Excellent	Good	—

[a] Depends on degree of stabilization.

continued on next page

Refractory Ceramics and Cermets—Fired or Sintered Parts

CARBIDES

Type →	Silicon Carbide			Boron Carbide
	Silicate-Bonded	Silicon Nitride-Bonded	Densified	
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.093	0.104	0.112	0.087[a]
Porosity, %	9–17	6–10	Negligible	Negligible
Ther Cond (2200 F), Btu/hr/sq ft/°F/ft	9	10	25[b]	16
Coef of Ther Exp (0–2550 F), per °F	2.4×10^{-6}	2.4×10^{-6}	2.17×10^{-6}	1.73×10^{-6}
Specific Heat (0–2550 F), Btu/lb/°F[a]	0.285	0.288	0.331	—
Max Service Temperature, F				
Inert Atmosphere	3200	3200	4000	4100
Oxidizing Atmosphere	2900	3000	3000	1000
MECHANICAL PROPERTIES				
Mod of Elast in Tension (77 F), psi	13.2×10^6	17×10^6	68×10^6	42×10^6
Tensile Strength (77 F), 1000 psi	Very low	3	25	22.5
Compressive Strength (77 F), 1000 psi	15	20	150	420
Modulus of Rupture (77 F), 1000 psi	2.2	5.5	24	50

[a] Boron carbide is available in densities ranging from 0.069 to 0.091 lb per cu in. [b] 1832 F.

CARBIDE-BASE CERMETS

Type (base) →	Titanium Carbide (TiC)[a]	Tungsten-Titanium Carbide ($WTiC_2$)[b]	Tungsten Carbide (WC)	Chromium Carbide (Cr_4C, Cr_7C_3, Cr_3C_2)[c]
Density, lb/cu in.	0.20–0.25	0.38–0.47	0.47–0.55	0.25–0.29
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	16.5–32.9	25.7–50.1	—
Coef of Ther Exp (68–1200 F), per °F	$4.3\text{–}7.5 \times 10^{-6}$	$3.5\text{–}4.0 \times 10^{-6}$	$2.5\text{–}3.9 \times 10^{-6}$	$5.8\text{–}6.3 \times 10^{-6}$[f]
Electrical Conductivity, % IACS	1.34–6.0	4.3–5.8	5.0–10.1	2.58–2.78
Mod of Elast in Tension, psi				
70 F	$42\text{–}57 \times 10^6$	$65.5\text{–}80.6 \times 10^6$	$61.6\text{–}94.3 \times 10^6$	—
1600–1800 F	$33\text{–}48 \times 10^6$	—	—	—
Tensile Strength, 1000 psi[d]				
75 F	26–134 (0–61)	118–145	130[e]	36–37 (0)
1500 F	45–94 (0–2.7)	—	—	20–42 (0.2)
1800 F	35–72 (0–2.4)	—	—	—
Hardness (Rockwell)	A73–A91	A90–A93	A85–A93	A86.5–A89
Impact Strength (unnotched Charpy), ft-lb				
75 F	1.5–16	5.3–8.9	—	—
1800 F	2.5–16	—	—	—
Transverse Rupture Strength, 1000 psi	122–236	125–300	175–385	100–120
Stress-Rupture Strength (100 hr, 1800 F), 1000 psi	8–28	—	—	—
Compressive Strength, 1000 psi	265–450	585–705	518–800	422–480

[a] Property range covers grades ranging from 17.5% to 90% TiC with different binder metal contents.
[b] Property range covers various grades of different carbide-metal proportions.
[c] The type of chromium carbide and the type of binder metal affects properties.
[d] Elongation (%) in parenthesis. [e] Typical of one grade. [f] 68–576 F.

Refractory Ceramics and Cermets—Fired or Sintered Parts

OTHER CARBIDES

Type ➡	Beryllium Carbide (Be_2C)	Titanium Carbide (TiC)	Columbium Carbide (CbC)	Tantalum Carbide (TaC)	Zirconium Carbide (ZrC)
Ther Cond (68–795 F), Btu/hr/sq ft/°F/ft.	12.1	9.9[a]	8.23[a]	12.8[a]	11.9[a]
Coef of Ther Exp (77–1472 F), per °F	5.8×10^{-6}	4.1×10^{-6}	—	4.6×10^{-6}	3.7×10^{-6}
Electrical Resistivity, ohm-cm[a]	1.1	1.05×10^{-4}	7.4×10^{-5}	2×10^{-5}	6.34×10^{-5}
Hardness (Mohs')	9+	8–9	9–10	9+	8–9
Compressive Strength, 1000 psi[a]	105	109	—	—	238
Mod of Rupture, 1000 psi[a]	16	—	—	—	—
Ther Shock Res (air quenched), cycles at designated temp range (F)	4 at 2000–1470	—	—	—	—
Fabrication Methods	Hot pressing, steel die pressing and sintering, hydrostatic pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering

[a] Room temperature.

MOLYBDENUM DISILICIDE (MoS_2)

Type ➡	Cold Pressed, Sintered	Hot Pressed
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.216	0.224
Melting Point, F	3685 ±90	3685 ±90
Electrical Resistivity, microhm-cm		
77 F	—	21.5–27.2
2900 F	—	75–80
Coef of Ther Exp (78–2700 F), per °F	—	5.1×10^{-6}
MECHANICAL PROPERTIES		
Tensile Strength, 1000 psi		
1800 F	—	40
2000 F	—	42
2200 F	—	43
2400 F	—	41
Hardness		
Rockwell	C57[a]	A80–87[b]
Knoop (1 kg)	1065	850–870
Compressive Strength, 1000 psi	100[c]	350
Modulus of Rupture, 1000 psi		
77 F	51	36–57
1800 F	51–67	—
2000 F	51–86	72
2200 F	d	55
Stress-Rupture Strength (100 hr), 1000 psi		
1600 F	—	35
1800 F	—	29
1900 F	—	13.5
2000 F	—	8.5

[a] Superficial hardness.
[b] Some indentation cracking.
[c] Cast specimens.
[d] Test not applicable because bars showed too much plasticity.

NITRIDES

Type ➡	Boron Nitride	Silicon Nitride[a]
PHYSICAL PROPERTIES		
Density, lb/cu in.		
Theoretical	0.081	0.124
Actual	0.076	0.111
Melting Point, F	>3000[b]	3452[c]
Ther Cond, Btu/hr/sq ft/°F/ft.	16.6, 15.4[d]	0.90[e]
Coef of Ther Exp (70–1800 F), per °F	4.3	1.37
MECHANICAL PROPERTIES		
Mod of Elast in Tension, 10^6 psi		
75 F	12.4×10^6	—
1300 F	1.5×10^6	—
Hardness		
Mohs	2	—
Rockwell	—	A99
Modulus of Rupture, 1000 psi		
75 F	15.9	10
1300 F	3.8	—
ELECTRICAL PROPERTIES		↑ Not applicable ↓
Volume Resistivity, ohm-cm		
75 F	1.7×10^{13}	
900 F	2.3×10^{10}	
1800 F	3.1×10^4	
Dielectric Constant (10^2–10^8 cps)	4.15	
Dissipation Factor		
10^2 Cycles	0.00103	
10^6 Cycles	0.00020	
10^{10} Cycles	0.0003	

[a] Mechanical properties are given for direction parallel to direction of forming pressure. Values perpendicular to this direction may be one-half to one-quarter of these values.
[b] May be used continuously at 3000 F, and higher under special conditions.
[c] Sublimes.
[d] Values at 570 F and 1800 F, respectively.
[e] 400–2400 F.

Glass (Industrial)—Flat, Pressed, Blown

Type ➡	Fused Silica	96% Silica	Soda-Lime Glasses		Aluminum Silicate
			Plate	General Purpose	
PHYSICAL PROPERTIES					
Density, lb/cu in	0.079	0.078	0.09	0.089	0.091
Softening Point, F	3050	2800	1330	1285	1675
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	0.80	0.80	0.53	0.53	—
Coef of Ther Exp (32-570 F), per °F	0.30×10^{-6}	0.45×10^{-6}	4.8×10^{-6}	5.1×10^{-6}	2.3×10^{-6}
Spec Ht, Btu/lb/°F	0.185	0.185	0.20	0.20	—
Elec Res (212 F), ohm-cm	$>10^{15}$	$>10^{15}$	—	4×10^{9}	$>10^{15}$
Power Factor (68 F, 1 mc), %	0.025	0.02-0.04	0.80	0.90	0.37
Dielec Const (68 F, 1 mc)	3.75	3.8	7.4	7.2	6.3
Ther Stress Res, °F[a]	—	390	—	65	85
Ther Shock Res, °F[b]	Very high	Very high	135	125	240
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	10×10^{6}	9.7×10^{6}	$9\text{-}10 \times 10^{6}$	$9\text{-}10 \times 10^{6}$	12.7×10^{6}
Normal Work Stress (annealed), psi	1000	1000	1000	1000	1000
Max Rec Svc Temp, F					
Annealed	1650	1500	900	840	1200
Tempered	—	—	550	480	840
THERMAL TREATMENT					
Annealing Temp (stress relief), F	2080	1670	1010	950	1315
FABRICATING PROPERTIES					
Workability	Glass can be ground or polished without great difficulty. Machining limited to sawing or drilling. Sawing readily accomplished with an impregnated wheel. Drilling is difficult, but is done with special carbide-tipped drills using kerosene as a lubricant				
Joining	Glass can be joined by heat sealing using a blast lamp, a gas torch or electric heating. Parts must have closely similar coefficients of expansion; otherwise, intermediate pieces having intermediate coefficients must be used. Glass-to-metal seals are also made by this latter process				
CHEMICAL RESISTANCE	Glass is attacked by hydrofluoric acid, hot concentrated phosphoric acid and strong alkalis. It is resistant to most other chemicals				
USES	Ultraviolet energy transmission, chemical apparatus, thermocouple protection tubes, laboratory apparatus	Ultraviolet energy transmission, chemical reaction vessels, thermocouple protection tubes, laboratory apparatus	Sheet and plate glass, molded glassware, bulbs for electric lamps, bottles, vials, fluorescent lamp tubing		

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[a] Measured by subjecting the two sides of a tube or constrained plate to a temperature differential. Index is the differential that causes a stress of 1000 psi on cooler surface.

[b] Measured by heating squares of annealed glass, 6 by 6 by ¼ in., to a uniform temperature and dropping into cold water. Index is maximum temperature differential at which no breakage occurs.

Glass (Industrial)—Flat, Pressed, Blown

Type ➡	Borosilicate Glasses			Lead Silicate Glasses	
	Low Expansion Chemical Resistant	Baking and Kovar Sealing	Low Electrical Loss	Lamp Tubing	High Lead
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.080	0.081–0.082	0.077	0.110	0.154
Softening Point, F	1500	1300–1425	—	1160	1075
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	0.67	—	0.67	0.50	0.45
Coef of Ther Exp (32–570 F), per °F	1.85×10^{-6}	$2.0\text{–}2.5 \times 10^{-6}$	1.8×10^{-6}	5.0×10^{-6}	5.1×10^{-6}
Spec Ht, Btu/lb/F	0.195	0.195	—	0.17	0.16
Elec Res (212 F), ohm-cm	10^{12}	3×10^{13}	$>10^{15}$	10^{14}	$>10^{15}$
Power Factor (68 F, 1 mc), %	0.46	0.26–0.28	0.06	0.16	0.09
Dielec Const (68 F, 1 mc)	4.6	4.7–5.1	4.0	6.6	9.5
Ther Stress Res, °F[a]	—	—	—	65	—
Ther Shock Res, °F[b]	320	—	—	120	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	9.8×10^6	—	6.8×10^6	9.0×10^6	7.6×10^6
Normal Work Stress (annealed), psi	1000	1000	1000	1000	1000
Max Rec Svc Temp, F					
Annealed	900	800–840	810	720	720
Tempered	550	420–500	450	380	360
THERMAL TREATMENT					
Annealing Temp (stress relief), F	1020	890–975	910	800	800
FABRICATING PROPERTIES					
Workability	Glass can be ground or polished without great difficulty. Machining limited to sawing or drilling. Sawing readily accomplished with an impregnated wheel. Drilling is difficult, but is done with special carbide-tipped drills using kerosene as a lubricant				
Joining	Glass can be joined by heat sealing using a blast lamp, a gas torch or electric heating. Parts must have closely similar coefficients of expansion; otherwise, intermediate pieces having intermediate coefficients must be used. Glass-to-metal seals are also made by this latter process				
CHEMICAL RESISTANCE	Glass is attacked by hydrofluoric acid, hot concentrated phosphoric acid and strong alkalis. It is resistant to most other chemicals				
USES	Heat exchanger tubes, chemical apparatus, cooking ware, electrical insulators, sight and gage glasses, containers for chemicals and medicines, metal sealing, industrial piping, industrial glassware requiring thermal resistance, special lighting ware, heat resisting lenses			Lamp tubing, electrical and electronic applications, thermometer tubing, metal sealing	Electrical capacitors, x-ray shielding

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[a] Measured by subjecting the two sides of tube or constrained plate to a temperature differential. Index is the differential that causes a stress of 1000 psi on cooler surface.

[b] Measured by heating squares of annealed glass, 6 by 6 by ¼ in., to a uniform temperature and dropping into cold water. Index is maximum temperature differential at which no breakage occurs.

Carbon and Graphite—Molded, Extruded

Material ➡	Carbon	Graphite
PHYSICAL PROPERTIES		
Density, lb/cu ft	93.3–102.0	93.3–102.0
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	3–5	70–86
Coef of Ther Exp (70–212 F), per °F	1.3-1.5 x 10^{-6}	1.0–1.3 x 10^{-6}
Specific Heat (100 F), Btu/lb/°F	0.18	0.18
MECHANICAL PROPERTIES		
Mod of Elast in Tension, psi	1.6–2.3 x 10^6	0.8–1.4 x 10^6
Tensile Strength, psi	900–1100	440–2000
Compressive Strength, psi	6300–9000	1700–7500
Flexural Strength, psi	2500–3000	800–4000
Hardness (scleroscope)	60–90	20–45
ELECTRICAL PROPERTIES		
Electrical Resistivity (68 F), microhm-cm	3500–4600	800–1300
Contact Resistance, ohms/sq in.		
Against Carbon	0.0058, 0.0026, 0.0017[a]	—
Against Copper	0.0133, 0.0093, 0.0042[a]	0.000704, 0.000315, 0.000162, 0.0000555[b]
Against Brass	0.038, 0.012, 0.0052[a]	0.00092, 0.000214, 0.000109[c]
Against Aluminum	0.138, 0.078, 0.015[a]	0.0448, 0.0067, 0.0020[c]
Against Graphite	—	0.000473, 0.000175, 0.000064, 0.000031[b]
Against Steel	—	0.01309, 0.00438, 0.00177, 0.000737[b]
FABRICATING PROPERTIES	Powdered material mixed with binder and shaped by molding under pressure or by extrusion, then baked above 1800 F	
CHEMICAL RESISTANCE	Carbon begins to oxidize in air at approximately 630 F and graphite at approximately 810 F, although the rate of oxidation is not rapid even at high temperatures. With a steam or a carbon dioxide atmosphere, temperature can be raised above a red heat before excessive oxidation occurs. Alkalis in solution do not attack these materials but fused hydroxides and carbonates attack them at high temperatures. They are not attacked by dilute acids, including hydrofluoric, but strongly oxidizing chemicals will attack them	
USES	Mechanical: sealing rings, pump and valve parts, bearings, pistons, and piston rings. Electrical: battery carbons, contacts, welding carbons, anodes, brushes for electrical machines. Refractory: linings, molds, continuous casting dies, furnace boats. Chemical: pipe, pumps, fittings, heat exchangers, valves, towers and accessories, porous filtering media	

[a] Pressures of 5, 25 and 75 psi, respectively.
[b] Pressures of 25, 150, 400 and 1000 psi, respectively.
[c] Pressures of 25, 150 and 400 psi, respectively.

Mineral Fibers

Type →	Glass			Asbestos			Ceramic (aluminum silicate)
	Standard	Micro		Chrysotile	Crocidolite	Amosite	
		Quartz	Glass				
COMPOSITION AND FORM							
Chemical Base	—	Silica glass	—	Hydrous magnesia silicates	Hydrous sodium and iron silicates	Iron and magnesium silicates	—
Color	Blue-white	Tan	—	Green, grey, white	Yellow-brown	Yellow-brown	Opaque white
Fiber Length, in.	Filament or staple	Staple	Staple	Crude ⅜-¾	Crude ⅜-2	2-11 in.	Very short
Fiber Width (avg), microns	5-16	0.75	0.05-1.5	0.1	—	—	3
PHYSICAL PROPERTIES							
Specific Gravity	2.54	—	2.54	2.4-2.6	3.2-3.3	3.1-3.25	—
Ten Str, 1000 psi	205-212	—	—	80-100	100-300	16-90	—
Elong, %	2-3.7	—	—	Low	Low	Low	—
Moisture Abs, %	Poor	Poor	Poor	Fair	Fair	Fair	Poor
Spec Ht, Btu/lb/°F	0.1	0.1	0.1	Contains 14% water	—	—	—
Specific Heat, Btu/lb/°F	0.157	—	0.157	0.266	0.201	0.193	—
Ther Cond (1000 F), 10^{-4} Btu/hr/sq ft/°F/ft	—	330-1000[a]	—	980[b]	—	—	190-1170[c]
Vol Res, ohm-cm	2×10^{11}	10^{15}	2×10^{11}	—	—	—	High
ENVIRONMENTAL PROPERTIES							
Acid Resistance	Resists all but hydrofluoric and hot phosphoric	Resists all but hydrofluoric and hot phosphoric	Resists all but hydrofluoric and hot phosphoric	Soluble to 57%	Good	Fair	—
Alkali Resistance	Dissolves in strong	Dissolves in strong	Dissolves in strong	Good	Good	Fair	—
Heat Resistance[d]							
Below 600 F	Exc	—	—	Exc	Loses water at mod temp	Fair, embrittles	Little effect, keeps resilience
600 F	Softens	OK	Softens	8.4% loss in ten str	Embrittles, loses character	Embrittles, loses character	OK
800 F	NG	OK	—	26.7% loss in ten str	NG	NG	OK
1000 F	NG	Shrinks slightly	Max (as felt)	40.5% loss in ten str	NG	NG	OK
1200 F	NG	Shrinks slightly	NG	68% loss in ten str	NG	NG	OK
2000 F	NG	Shrinks slightly	NG	Embrittles, loses character	NG	NG	OK—still resilient
Fusing Temp, F	1500	2500	1500	2770	2180	2550	2800

[a] Felted; density 3 lb per cu ft.
[b] 75 F.
[c] Felted.
[d] NG = No good.

Synthetic Fibers

Type ⇒	**Regenerated Cellulose** (rayon)				**Cellulose Acetate** (acetate)	**66 Nylon**			**Fluorocarbon (Teflon)**	**Polyester (Dacron)**
	Viscose									
	High Tenacity[a]	**Regular**	**Cuprammonium**	**Fortisan 36**						
COMPOSITION AND FORM										
Chemical Base	Regenerated cellulose		Regenerated cellulose	Saponified cell. acetate	Cellulose acetate	Polyamide			Polytetrafluoroethylene	Polyethylene terephthalate
Color	White	—	White	White	White	White			Brown	White
Fiber Width (avg), microns	10-15	10-43	11	—	11-46	10+			—	—
Cross Section	Irregular	—	Circular	Irregular	Irregular	Circular			Circular	Circular
PHYSICAL PROPERTIES										
Specific Gravity	1.5	1.5	1.54	1.52	1.3	1.14			2.3	1.38
						Reg	High	Staple		
Ten Str 70 F, 65% RH, 1000 psi	85-95	29-47	33-42	138-155	20-25	67-85	89-108	60-66	44	85-106
Wet, % of normal	55-65	44-54	59	65-70	60-65	100	100	100	100	98
Elong, %	10-20	15-30	10-17	6.2	23-30	26-32	19-24	37-40	24	12-40
Stiffness, gm/grex	25	11	14	—	5.2	20	41-47	—	—	13-25
Strain Rec (2% strain unless noted), %	82	82	48 at 5%	—	94	100[b]	100[b]	100[b]	—	90-100
						75 at 20%				
Toughness Index (relative work to rupture)	25	19	14	—	19	56	52	—	Good	49-63
Friction Coef (Self)	0.19	—	—	—	0.29	0.14-0.16			Low	—
Flammability	Highly flammable		Highly flammable	Burns	Burns	Not support combustion			Fire resistant	Slow burn
ENVIRONMENTAL PROPERTIES										
Acid Resistance										
Strong	Decomposes		Decomposes	Poor	Decomposes	Poor			Inert	Good at low temp
Weak	Strength loss		Decomposes	Poor	Dissolved by some	Fair			Inert	Res
Alkali Resistance										
Strong	Swells		Swells	Swells	Saponifies	Good			Inert	Fair at low temp
Weak	Res (cold)		Res (cold)	Res (cold)	Res (cold)	Good			Inert	Good at low temp
Organic Solvents	Res		Res	Res	Dissolved by many	Generally insoluble			Inert	Res
Sunlight Effect	Weakens		Res	Res	Weakens	Weakens			Inert	Weakens
Microbiological Res	Attacked		Attacked	Attacked	Res	Res			Inert	Res

[a] Super Cordura.

[b] Delayed recovery up to two weeks.

Synthetic Fibers

Type →	Acrylic			Vinyl Derivative			Protein (Vicara)
	Orlon	Acrilan	Dynel	Vinyon	Saran	Polyethylene	
COMPOSITION AND FORM							
Chemical Base	Polyacrylonitrile	Acrylic copolymer	Vinyl chloride-acrylonitrile copolymer	Vinyl chloride-vinyl acetate	Vinylidene chloride	Polyethylene	Zein (corn protein)
Color	Cream	White	Light cream	White	White	White	Beige-white
Fiber Width (avg), microns	—	—	—	16–18	50–1300	150+	15–30
Cross Section	Flattened tube	Flattened tube	Flattened tube, convoluted	Bar bell	Circular	Circular	Circular
PHYSICAL PROPERTIES							
Spec Grav	1.14–1.17	1.2	1.30	1.33	1.68–1.75	0.92	1.25
Ten Str							
70 F, 65% RH, 1000 psi	77	44–66	42–45	35–76	15–45	11–32	17.5–19
Wet, % of normal	95	80	100	100	100	100	45–55
Elongation, %	16	31	33–38	14–35	20–30 at break (oriented)	20–80	30–35
Stiffness, gm/grex	28–30	8	6.3	22	20	2–12	2.8–3.4
Strain Rec (2% strain unless noted), %	85	80	97	99	95	90–95 slow	99 at 4%
Toughness Index (relative work to rupture)	44	32–40	48	30–36	—	30	18–21
Friction Coef (self)	—	—	—	0.19	—	—	—
Flammability	Slow burn	Slow burn	Self-extinguishing	Not support combustion	Not support combustion	Slow burn	Burns
ENVIRONMENTAL PROPERTIES							
Acid Resistance							
Strong	Inert	Inert	Res	Res	Res	Res	Res to 10% conc
Weak	Inert	Inert	Res	Res	Res	Res	Decomposes
Alkali Resistance							
Strong	Attacked	Attacked	Very res	Res	Res most	Res	Decomposes
Weak	Fair-good	Fair	Very res	Res	Res	Res	Res (cold)
Organic Solvents	Generally res	Very res	Generally good	Poor	Generally res; swells	Generally good	Res
Sunlight Effect	Very res	Res	Slight str loss	Res	Tends to yellow	Weakens	Res
Microbiological Resistance	Res	Res	Res	Res	Res	Res	Res

Natural Fibers

Type →	Cotton	Bast				Hard			Animal		
		Flax	Jute	Hemp	Ramie	Manila (abaca)	Sisal	Hennequin	Wool	Horsehair	Silk
FORM											
Fiber Length, in.	½–2½	6–40	10–60	40–80	15–25	20–40	24	20	1½–15	1–25	Filament
Fiber Width (avg), microns	17	16	17	20	47	19	19	20	28	100	11
Cross Section	Flat tube	Tube	Bunched cells	—	Flat tube	Bunched cells	Bunched cells	Bunched cells	Round	Round	Round
PHYSICAL PROPERTIES											
Specific Gravity	1.55	1.50	1.48	1.48	1.55	—	—	—	1.30	1.30	1.60
Ten Str											
70 F, 65% RH, 1000 psi	42–125	115	—	112–132	130	125	100–120	—	17–28	—	45–83
Wet, % of normal	120	—	Low	Low	High	High	Low	Low	79–97	—	75–95
Elong, %	3–10	3	—	2–6	3–6	2–3	2–2.5	—	25–50	—	13–31
Stiffness, gm/grex	57–60	270	185	200	167	175	127	—	3.9	—	0.75–1.16
Strain Rec (2% strain unless noted), %	74, 45 at 5%	65	74 at 1%	—	52	—	—	—	99+, 63 at 20%	99, 63 at 20%	74
Toughness Index (relative work to rupture)	14	6	2	4	8	7	5	—	20	—	44
Strength Ratio (yarn to fiber)	0.45–0.60	0.38	0.35	0.36	0.45	—	—	—	0.50–0.55	—	—
Friction Coef (self)	0 30	—	—	—	—	—	—	—	0.20–0.50	—	0.26
Flammability	Burns	Burns	Burns	Burns	Burns	Burns	Burns	Burns	Slow burn	Slow burn	Burns
ENVIRONMENTAL PROPERTIES											
Acid Resistance											
Strong	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Res	—	Dissolves
Weak	Poor	Poor	—	Poor	—	—	—	—	Res	—	Fair
Alkali Resistance											
Strong	Exc	Good	Good	Good	Good	Good	Good	Good	Poor	Poor	Dissolves
Weak	Exc	Good	Good	Good	Good	Good	Good	Good	Poor (hot)	Poor	Poor
Organic Solvents	Res	Res	Res	Res	Res	Res	Res	Res	Res	Res	Res
Heat Effect	Good to 275 F	Good to 275 F	—	Good to 275 F	Good to 275 F	—	—	—	Good to 212 F	—	Disintegrates at 340 F
Sunlight Effect	Weakens	None	None	None	None	None	None	None	Weakens	Weakens	Weakens
Microbiological Resistance	Poor	Very good	Good	Good	Exc	Good	Poor	Poor	Fair	Fair	Good

Woods and Wood-Base Compositions—Board, Molded

AMERICAN WOODS[a]

Hardwood Type[b] ↓	Specific Gravity	Bending Stress, psi[c]	Max Crushing Str (compr), psi[d]	Softwood Type[e] ↓	Specific Gravity	Bending Stress, psi[c]	Max Crushing Str (compr) psi[d]
Ash (white)	0.60	8,900	7,410; 1,410	**Cedar** (Port Orford)	0.42	7,700	6,470; 760
Basswood	0.37	5,900	4,730; 450	**Cedar** (eastern red)	0.47	3,800	6,020; 1,140
Beech	0.64	8,700	7,300; 1,250	**Cypress** (southern bald)	0.46	7,200	6,360; 900
Birch (yellow)	0.62	10,100	8,170; 1,190	**Douglas Fir** (coast type)	0.48	8,100	7,420; 910
Cottonwood (black)	0.35	5,300	4,420; 370	**Fir** (balsam)	0.36	5,200	4,530; 380
Elm (rock)	0.63	8,000	7,050; 1,520	**Hemlock** (eastern)	0.40	6,100	5,410; 800
Gum (sweet red)	0.49	8,100	5,800; 860	**Hemlock** (western)	0.42	6,800	6,210; 680
Gum (tupelo)	0.50	7,200	5,920; 1,070	**Pine** (eastern white, northern white)	0.36	6,000	4,840; 550
Hickory (shagbark)	0.69	8,900	8,000; 2,220	**Pine** (longleaf)	0.58	9,300	8,440; 1,190
Locust (black)	0.69	12,800	10,180; 2,260	**Pine** (ponderosa)	0.40	6,300	5,270; 740
Maple (sugar)	0.63	9,500	7,830; 1,810	**Redwood** (virgin)	0.40	6,900	6,150; 860
Oak (red)	0.63	8,400	6,920; 1,260	**Spruce** (Sitka)	0.40	6,700	5,610; 710
Oak (white)	0.68	8,200	7,440; 1,320				
Poplar (yellow)	0.40	6,100	5,290; 580				
Walnut (black)	0.55	10,500	7,580; 1,250				
Willow (black)	0.37	3,900	3,420; 480				

[a] Test pieces air dried to 12% moisture content.
[b] "Hardwood" refers to deciduous trees (lose leaves seasonally); the term has no relation to the hardness of the wood.
[c] Static bending stress at the proportional limit. [d] First value is longitudinal, second is transverse.
[e] "Softwood" refers to coniferous trees (retain leaves); the term has no relation to the softness of the wood.

WOOD COMPOSITION BOARD

Class →	Hardboard (fibrous)[a]			Particle Board[b]		Softboard (insulation)[c]		
	Untreated	Treated	Special Densified	Low Density[d]	High Density	Semirigid	Rigid	Intermediate Density
PHYSICAL PROPERTIES								
Specific Gravity	0.88–1.04	0.95–1.15	1.35–1.45	0.40–0.80	0.80–1.05	0.02–0.15	0.15–0.40	0.40–0.80
Density, lb/cu ft	50–65	60–70	85–89	25–50	50–70	1.5–9	9–25	25–50
Ther Cond, Btu/hr/sq ft/°F/in.	0.80–1.40	1.50	1.85	0.40–0.80	—	0.24–0.27	0.27–0.40	0.40–0.80
Water Abs (24 hr), %	3–18	3–13	0.3–1.2	5–50	15–40	—	—	—
Max Linear Exp, %[e]	0.60	0.40	—	0.40	0.85	—	0.50	1.30
MECHANICAL PROPERTIES								
Ten Str, psi								
Par. to Surface	1000–3000	4000–5500	7700	100–1350	300–2500	—	200–500	800–2000
Perp to Surface	—	—	500	90–400	275–400	—	10–25	—
Mod of Elast in Bend, 1000 psi	400–800	800–1000	1250	300–700	400–1000	—	25–125	90–700
Compr Str (par.), psi	1800–6000	4200–5300	26,500	—	3500–4000	—	—	500–3400
Mod of Rupture, 1000 psi	3–7	7.5–10	10–12	0.4–4.0	3.0–7.5	—	0.2–0.8	0.4–4.0

[a] Made by felting ligno-cellulosic wood fibers formed by steam exploding or mechanical fiberizing.
[b] Made of flakes, chips, splinters or particles of wood bonded with synthetic resin or other binder.
[c] Made from wood pulp or bagasse (processed sugar cane), bonded by felting properties of fiber. [d] Does not include extruded board.
[e] Expansion resulting from change in moisture content from equilibrium at 50% RH to equilibrium at 97% RH.

WOOD COMPOSITION MOLDINGS

Resin Binder ↓	Molded Density, lb/cu ft	Mod of Rupture, 1000 psi	Rockwell R Hardness	Water Absorption (24 hr), %	Shrinkage, in./in.
Urea (15%)	62.4	3.1–3.7	26–46	30–50	0.003–0.008
Phenolic					
10%	56.2, 68.7	2.3–2.9, 4.5–5.1	18–38, 62–82	25–50, 10–25	0.001–0.005, —
15%	56.2, 68.7	3.6–4.2, 6.5–7.1	39–59, 73–93	25–45, 5–20	—
20%	56.2, 68.7	5.4–6.0, 7.9–8.5	60–70, 76–96	10–25, 3–8	—, 0.003–0.008
Melamine (15%)	62.4	3.6–4.2	37–57	15–35	0.003–0.008

Mechanical Felts—Sheet, Roll

SHEET AND ROLL FELTS

Type[a] ↓	Nominal Density, lb/cu ft	Typical Applications	Classification[b]
SHEET FELT			
Rock Hard	43	Heavy duty grinding and polishing wheels, bumpers	32-S-1, 32-S-2, 32-S-3, 32-S-4
Hard	35	Polishing granite, marble, glass tumblers; marking pens	26-S-1, 26-S-2, 26-S-3, 26-S-4
Medium	27	Polishing lenses, mirror and plate glass, and wood; cash carrier heads, bumpers, ink rollers, punched wicks	20-S-1, 20-S-2, 20-S-3, 20-S-4
Soft	21	Wicks, washers, plugs, transfer rolls, polishing blocks	16-S-1, 16-S-2, 16-S-3, 16-S-4
Extra Soft	16	Fine and soft metal polishing, absorbent pads, shock mountings, antivibration pads	12-S-1, 12-S-2, 12-S-3, 12-S-4
ROLL FELT			
Back Check (F-1, F-2, F-3)	21	Washers, bushings, wicks, ink rolls and pads, door bumpers, polishing blocks, wheels and pads, antivibration and dampening pads, window channels, oil and grease shields	16-R-1, 16-R-2, 16-R-3
Extra Firm Pads (F-5, F-6, F-7)	16	Dust shields, wipers, grease-retaining washers, wicks, antivibration mountings	12-R-1, 12-R-2, 12-R-3
Firm Pads (F-10, F-11, F-12, F-13, F-15)	11.3	Grease and oil retainers, dust shields, sound deadening, chassis strips, pedal pads, dash liners	9-R-1, 9-R-2, 9-R-3, 9-R-4, 9-R-5
Soft Pads (F-26)	9.6	Packing and padding	8-R-16
Ball Bearing (F-50, F-51)	21	Ball and roller bearing oil retainers; small dust-excluding washers; gaskets, liners, other thin cut parts	16-RX-1, 16-RX-3
Lining (F-55)	16	Antisqueak strips; lining cemented to fiber board and metal panels	12-RX-3

[a] SAE Spec No. in parenthesis.

[b] Felt classifications are based on the construction, i.e., fiber blends or "mixes," and density of the material. Several types, serving assorted uses, are customarily fabricated in each of the principal classes.

Standard nomenclature consists of a three-unit code in which the first number indicates the surface density (weight equivalent of 1 sq yd 1 in. thick); a letter ("S" for felts fabricated in sheets 36 x 36 in., "R" for felts fabricated in rolls 40 yd long and 60 or 72 in. wide); and a second number indicating the type of fiber composition, which has a basis in the U. S. Standard wool grade classification.

FILTER FELTS

Type[a] ↓	Nom Thk, in.	Density, lb/cu ft	Mullen Bursting Strength, psi[b]	Porosity, %	Air Permeability, cfm/sq ft/ 0.5 in. H_2O	Retention Efficiency, %[c]	Use
A (all wool)	1/32	10	50	93	280	45	Multilayer latex filter
B (all wool)	1/16	9	94	86	235	65	Air conditioning and pollen filtering
C (all wool)	1/16	11	125	86	130	76	Emulsion and dope
D (all wool)	1/16	13	130	86	105	88	Industrial air conditioning
E (all wool)	3/64	14	110	83	70	92	Air compressors; compressed air
F (cotton blend)	3/32	11	225	86	50	94	Cellulose lacquer and organic solvents
G (all wool)	3/32	17	220	66	30	96	Oil and fuel
H (all wool)	1/16	20	145	79	28	98	Industrial respirators and masks
I (all wool)	1/16	22	120	79	13	99	Biochemical air intake filters
J (silk blend)	1/16	30	235	62	2	100	Toxic dusts, fumes and mists

[a] Filter felts are made of special wool fiber blends chosen for their ability to make a felt of specific porosity, permeability and retention characteristics.

[b] ASTM D461-53.

[c] Retention of 0.7 micron mean dia mineral dust at rated permeability.

Mechanical Felts—Sheet, Roll

ROLL FELTS[a]

SAE Spec No.	Nom Thk, in.	Density, lb/cu ft	Breaking Strength, psi		Splitting Resistance (2-in. width), lb		Wool Content, %	Solubles, %			Ash, %
			L[b]	W[b]	L[b]	W[b]		Carbon Tetrachloride	Water	Combined	
F-1	¼	22.1	810	835	38	36	98	0.9	0.9	1.9	0.5
	½	19.3	850	720	42	44	98	0.8	1.5	2.3	0.6
F-3	¼	20.0	450	490	26	24	94	2.1	1.7	3.8	1.2
	½	20.1	475	550	32	29	95	2.1	1.2	3.3	1.0
F-5	¼	15.0	640	450	18	18	98	1.1	1.4	2.4	0.7
	½	15.4	640	565	21	19	97	0.6	1.6	2.2	0.6
F-10	¼	11.4	380	280	9	8	98	0.6	1.1	1.8	0.6
	½	11.0	400	325	8	8	98	0.5	1.3	1.8	1.0
F-11	¼	11.8	310	230	8	9	94	3.1	1.6	4.7	1.0
	½	12.2	300	240	9	9	94	3.7	1.2	4.9	0.9
F-15	¼	10.7	170	130	6	5	86	1.6	2.8	4.4	1.8
	½	11.2	180	130	4	4	88	1.7	2.8	4.5	1.9

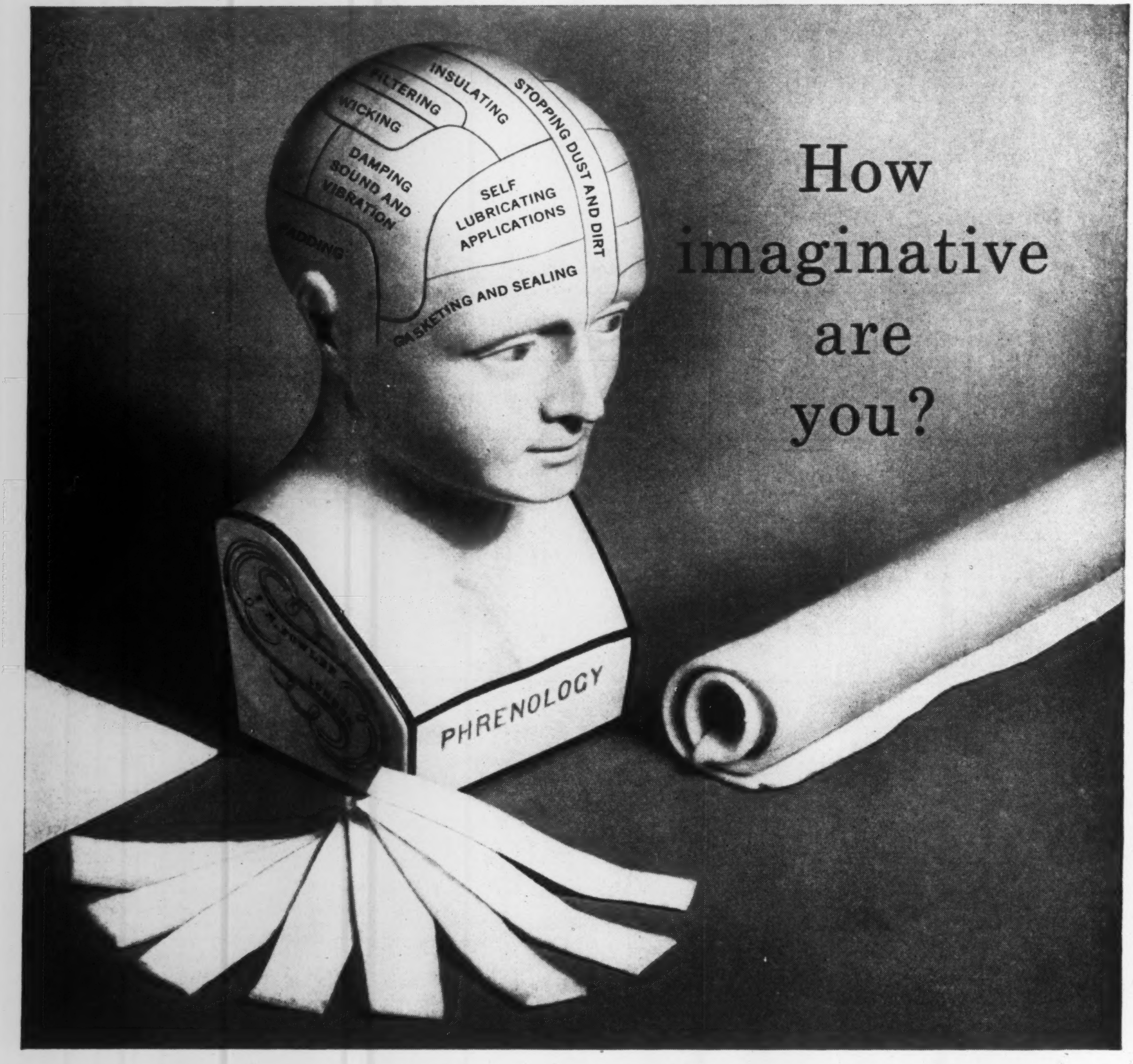
[a] Typical test data obtained by ASTM D461 methods; not specifications.
[b] L=lengthwise; W=transverse.

SAE Spec No.	Abrasion Wear, % decr in thk[a]			Coef of Static Friction[b]				Oil Absorption and Capillary Flow (SAE 20 oil, 70 F)								Ther Cond (K), Btu/hr/sq ft/°F/ft[c]
	Load, oz/sq in.							Oil Absorption (24 hr), % wt incr	Oil Wicking Rate, in./min lapsed time							
	3.8	7.0	10.2	Wood	Glass	Metal	Oiled Metal		5	10	15	30	60	90	120	
F-1	1.0	2.3	2.1	.37	.26	.22	.18	185	0.5	0.7	0.8	1.1	1.6	2.0	2.2	0.030
F-3	2.1	2.1	3.0	.37	.26	.22	.18	265	0.5	0.7	1.0	1.3	1.7	1.8	2.1	0.030
F-5	3.0	3.0	6.0	.37	.26	.22	.18	320	0.6	0.8	1.0	1.3	1.7	1.9	2.0	0.025
F-15	4.1	7.6	18.5	—	—	—	—	570	0.6	0.9	1.1	1.4	1.6	1.8	1.9	0.020

[a] Felt-to-felt, 10,000 rubs, 8-in. stroke. [b] Felt against material indicated.
[c] 1-in. felt. Thermal and acoustical felts blended with Kapok fiber nave tested values of 0.21 K factor and 0.80 sound absorption coefficient at 512 cps for 1-in. thicknesses of 3.2 lb per sq yd weight.

SAE Spec No.[a]	F-1 (21)		F-3 (21)		F-5 (16)		F-10 (11.3)		F-11 (11.3)		F-15 (11.3)	
	Load, psi	Compr Set, %	Load, psi	Compr Set, %	Load, psi	Compr Set, %	Load, psi	Compr Set, %	Load, psi	Compr Set, %	Load, psi	Compr Set, %
Deformation, %												
10	21	1	13	1	6	1	4	1	4	1	3	1
30	110	4	93	6	41	4	9	3	15	4	10	4
50	480	11	420	12	215	10	58	9	72	9	64	10
80	27,900	53	21,200	55	7750	53	2380	40	2620	42	3420	42

[a] Density (lb per cu ft) given in parenthesis.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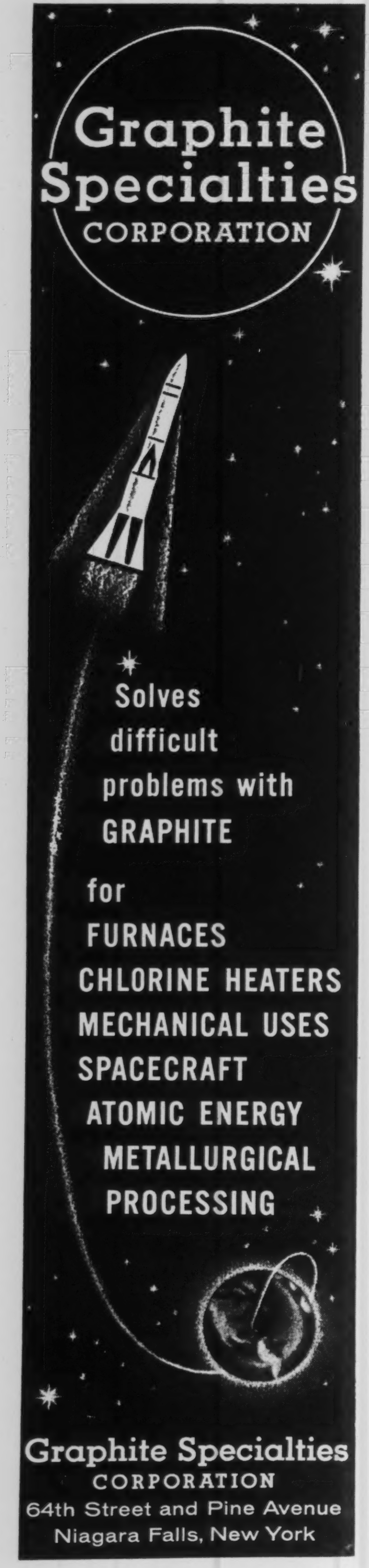

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BUTYL	●	●			
"HYPALON"*		●	●	●	
ACRYLIC			●	●	
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"VITON"*			●	●	●

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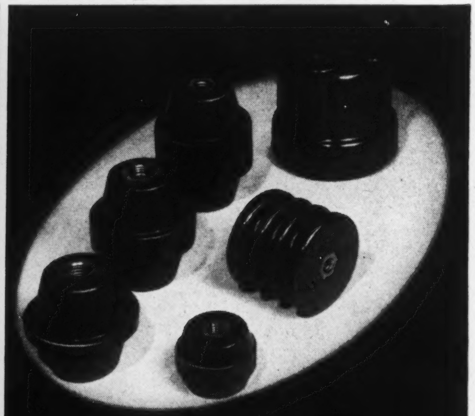

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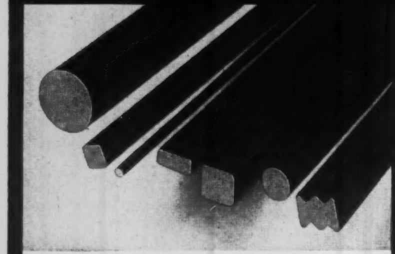

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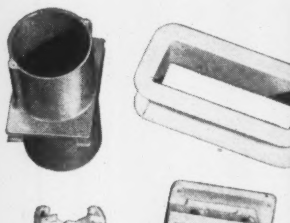

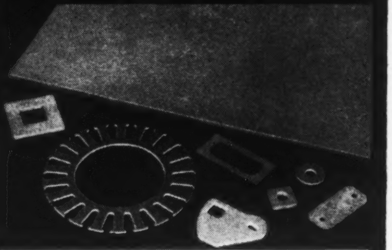

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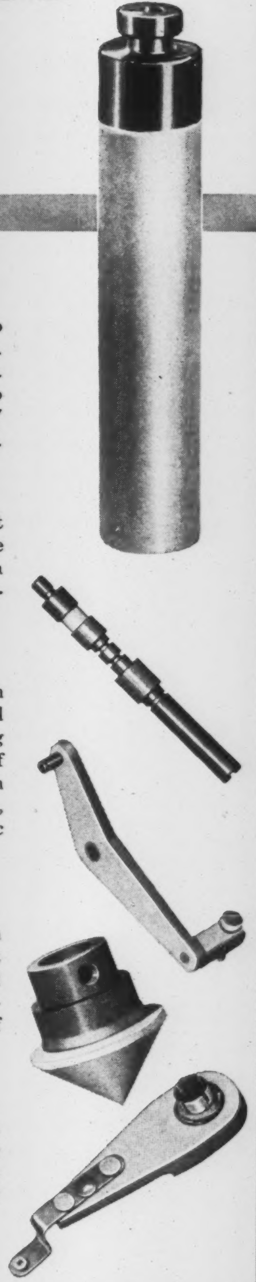

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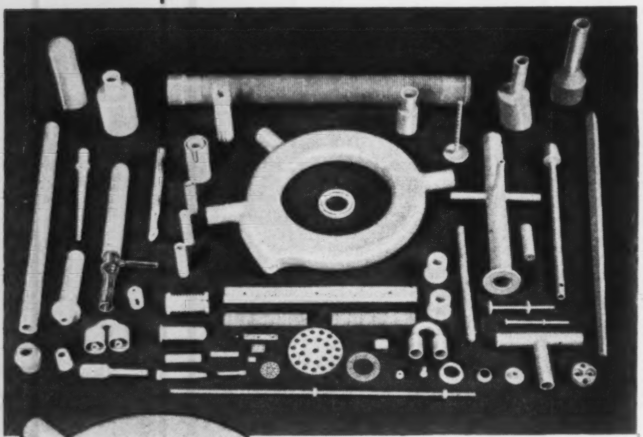

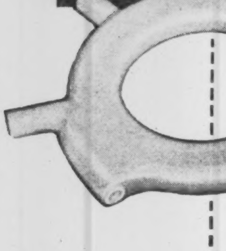

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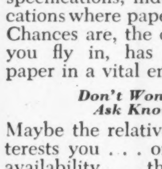

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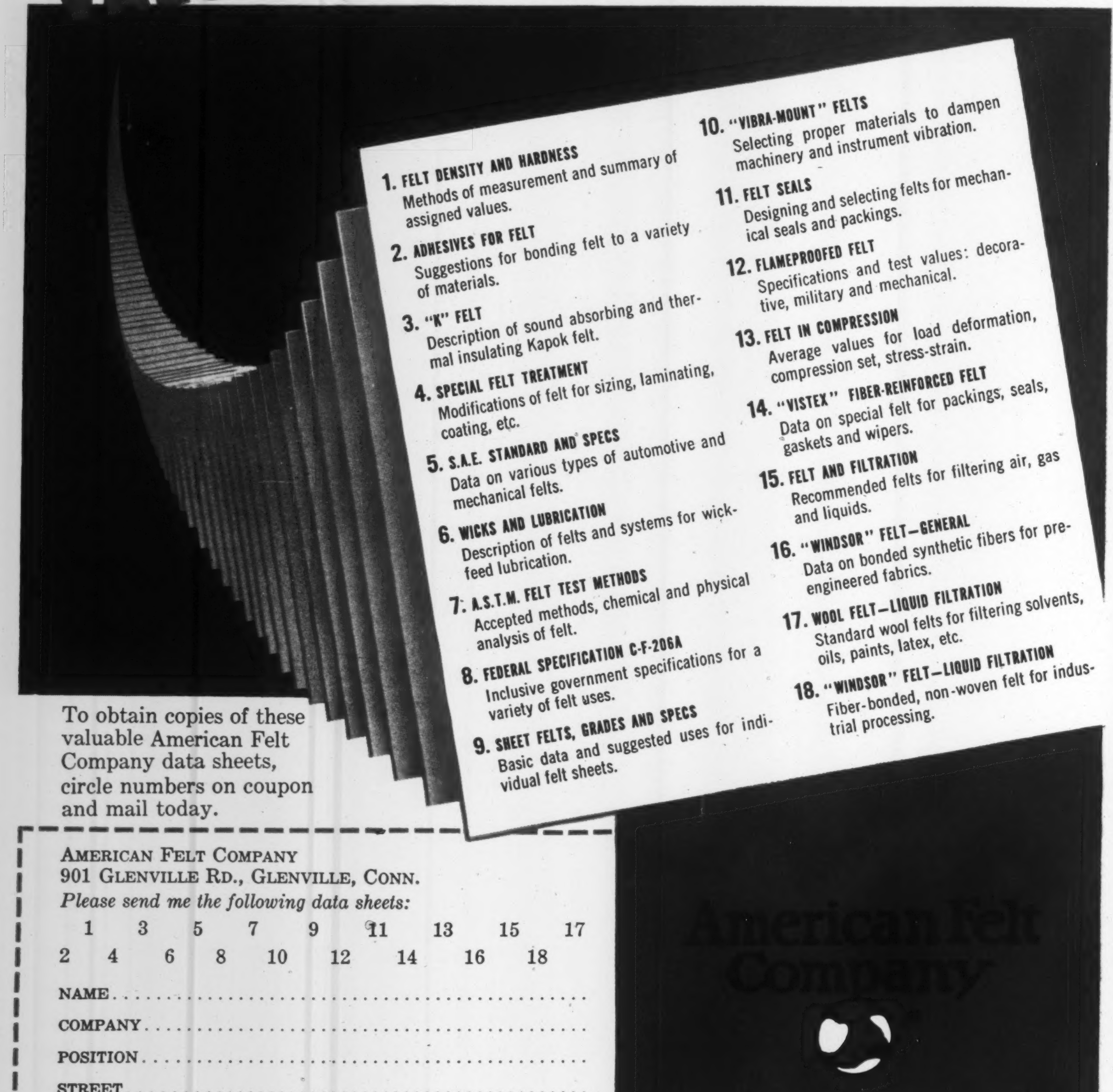

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Electrical stability. Corning glasses have high resistivity, low power losses, low and high dielectric constants, excellent non-tracking properties. They can also be furnished with special characteristics of high dielectric strength.

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Lime glasses have controlled mechanical properties and excellent visual qualities.

Lead glasses have controlled mechanical and electrical properties and high visual quality.

WHERE GLASS?

Because you can get Corning glass in almost any shape or form you wish—because you can be sure of the definite and fine balance of properties required for your specific needs, you can use Corning glass in a wide range of applications. Some of these are:

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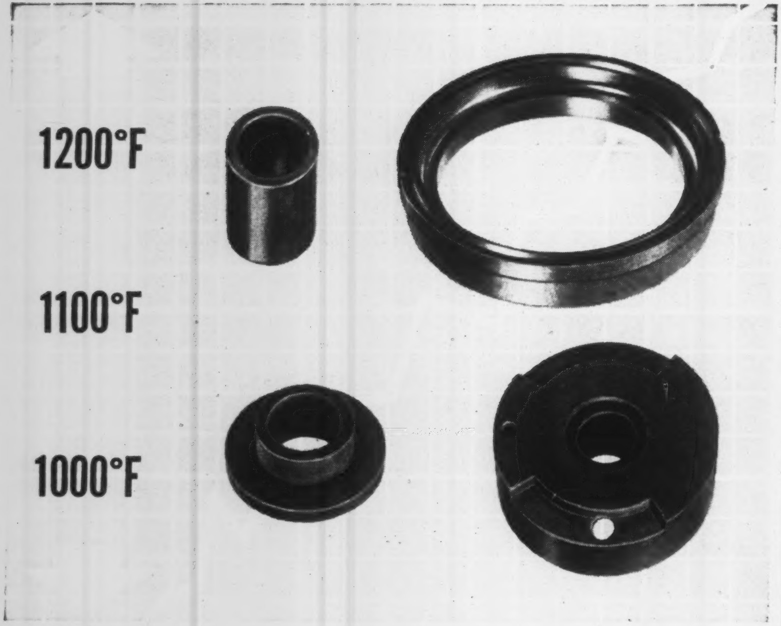

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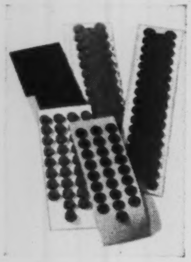

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by D. V. ROSATO

Assistant Plant Manager
Research Division, Plastics Plant
Raytheon Manufacturing Co.

1959, 224 pages, $5.75

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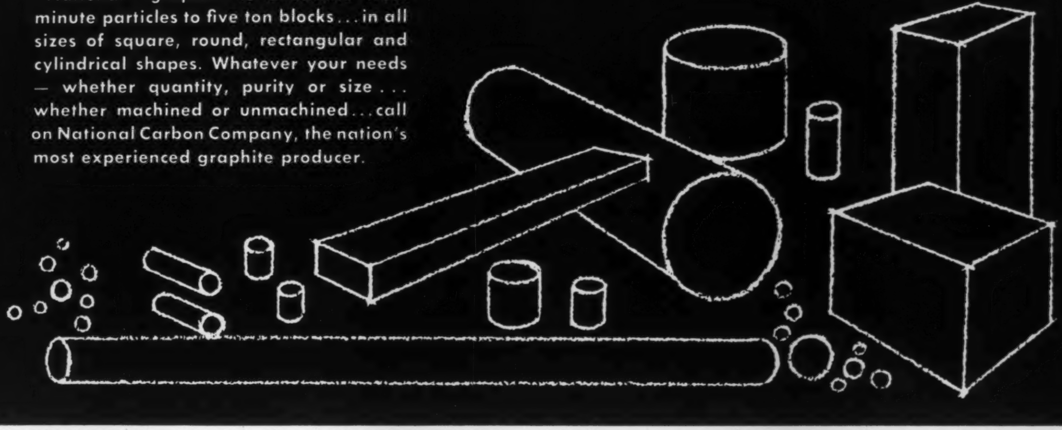

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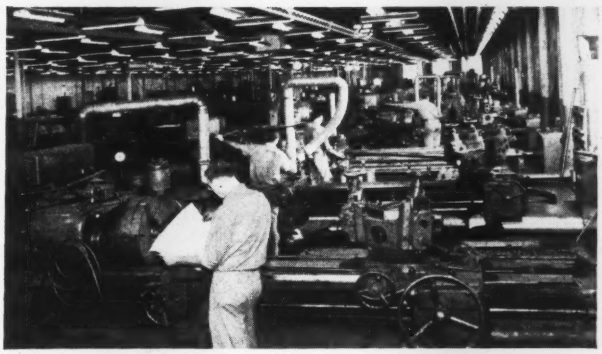

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1954, 250 pages, $4.50

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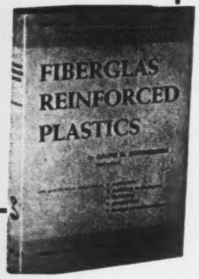

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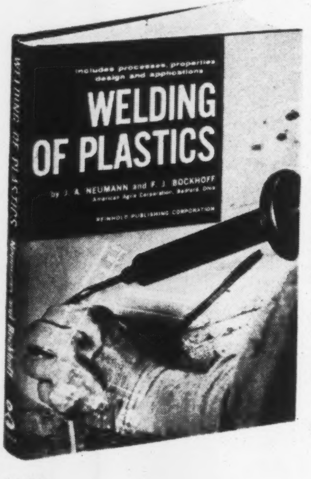

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Pure Carbides	Low binder content. High melting point.	Crucibles. Acid resistant parts. High temperature furnace parts.
Heavy Tungsten Alloys	Nominal Density: 16.5 to 18.7 gm/cc. Machinability: Good. Tensile Strength: 40,000 to 90,000 psi. Corrosion Resistance: Excellent. Readily brazed with Easy-Flo No. 3 Compound. Available as bars, rods, rings, discs, special shapes.	Counterweights. Radioactive shielding. Isotope containers. Atomic watch shielding. Shielding — cobalt and X-ray medical equipment. Rotational parts — flywheels, governors, gyroscope components. Electrical contactors for high current heavy duty applications.
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Tantalum	Metal — 99.9% (capacitor) grade. Solid form — strip, bar, foil, wire. Metal — 99.5% grade. Granules. Metal Powder — 99.8% grade. Fine powder. Oxide — 99% grade. Fine powder.	Bars: Nominal size ½" x 2" x 19". Other sizes available. Strip, Foil: .001" to .100" thick, up to 4" wide. Wire: From .005" to .030". Granules: 20 mesh. Other sizes and grades available. Powder: 200 mesh. Other sizes available. Oxides: In analyses and particle sizes to meet specific requirements.
Kenspray (hard surfacing material)	Powder applied by hand or mechanically-held metal spraying equipment. May be successfully applied to irregular shapes or flat surfaces. Only thin coating required (from .010" to .090"). Conserves material, provides uniform surface. After spraying application, part is heated to fuse the hard surfacing deposit to its base. For close tolerances, part may then be ground with silicon carbide wheels.	Machine components and equipment for food, chemical, petro-chemical, other processing industries . . . Cams, valve seats, sleeves, shafts, dies, guides, jigs, process rolls, wear strips, valve plugs and bodies, grain mill hammers, pump parts, agricultural equipment.
Kenplate (hard surfacing material)	Factory assembled as small, hexagonal plates in a uniform mating pattern on flexible woven-glass backing. Plate thicknesses from .062" to .250" in two hex sizes. May be applied by standard epoxy bonding, silver soldering, conventional brazing.	Wear plates in processing equipment. Liners for ball mills, inclined chutes for abrasive materials. Centrifuge surfaces. Slide surfaces, guide rails for materials handling equipment.

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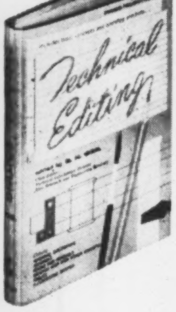
1958, 288 pages, $5.75



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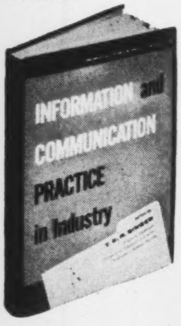

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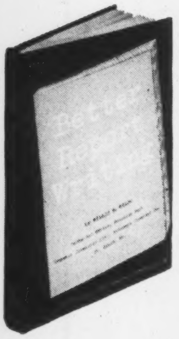

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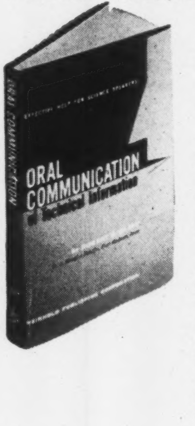

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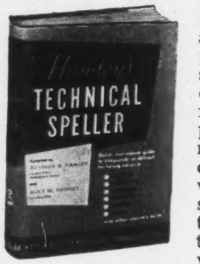

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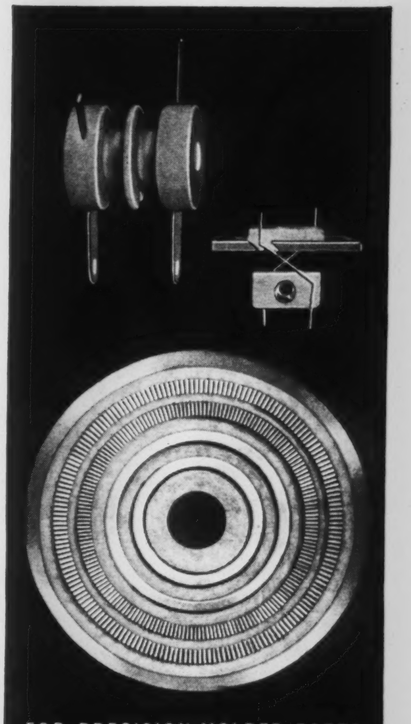

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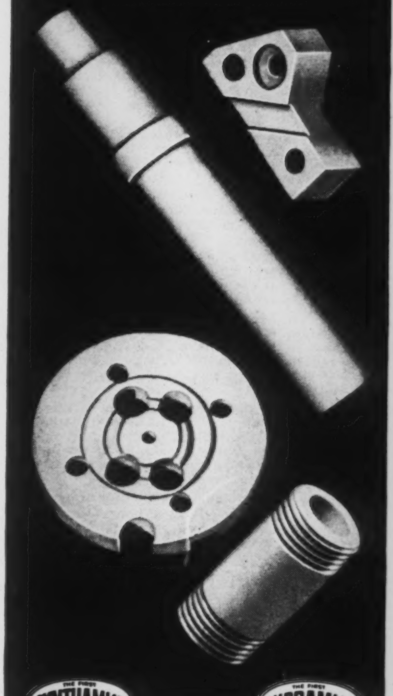

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Electrodeposited Coatings

Type ➡	Aluminum	Antimony	Arsenic	Bismuth	Cadmium	Chromium
BASE METALS	Magnesium, steel, copper, zinc, nickel, silver, gold	(experimental)	Brass	(experimental)	Steel, copper and its alloys, cast and malleable iron	Ferrous and nonferrous metals
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	122	10.2	—	4.6	5.3	—
Elec Res, microhm-cm	2.8	41.7	35	119	7.5	14–66
Color (natural)	White	White (bright)	Gray or black	White or gray	White (bright)	White (bright) or black
Reflectance When Polished (5000 A), %	—	50	—	—	—	—
Melting Point, F	1220	1166	1139	520	610	2939
Min Thickness, mil	0.1	—	—	—	0.15	0.01
MECHANICAL PROPERTIES						
Brinell Hardness	—	—	—	—	35–50	700–1000
Abrasion Resistance[a]	Poor	—	—	—	Fair	Excellent
CORROSION RESISTANCE, 10^{-6} ipy						
Atmosphere	—	—	—	—	250–510	—
Sea Water	20–3400	—	—	—	700	—
SOLDERABILITY						
As Plated	—	—	—	—	Good	Poor
After 192-Hr Salt Spray	—	—	—	—	Poor	Poor
COST	Moderate	—	—	—	Moderate	Moderate
USES[b]	c, e	c, d	D	c	C, d, w	c, D, e, R, W

Type ➡	Cobalt	Copper	Gold	Indium	Iron	Lead
BASE METALS	Iron, steel, copper and its alloys	Most ferrous and nonferrous metals	Copper, brass, nickel, silver	Silver-plated steel	Ferrous metals	Most ferrous and nonferrous metals
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	—	222	169	—	38.7	20.1
Elec Res, microhm-cm	6.2	3–8	2.4	8.4	10	22.6
Color (natural)	Gray	Pink or red (bright)	Yellow (bright)	White	Gray	Gray
Reflectance When Polished (5000 A), %	—	44	47	—	0.55	—
Melting Point, F	2723	1981	1944	311	2795	621
Min Thickness, mil	—	0.1	0.002	0.1	—	0.25
MECHANICAL PROPERTIES						
Brinell Hardness	—	60–150	5	—	150–300	5
Abrasion Resistance[a]	—	Fair	Poor	Poor	Good	Poor
CORROSION RESISTANCE, 10^{-6} ipy						
Atmosphere	—	54–464	—	—	—	9–27
Sea Water	—	2000	—	—	—	100–600
SOLDERABILITY						
As Plated	—	Good	Good	Good	Fair	—
After 192-Hr Salt Spray	—	—	Good	—	Poor	—
COST	—	Low	High	—	Low	Low
USES[b]	c, e, r	c, d, E	c, D, e	c, d, W	e, R, w	C, e, w

Notes: See opposite page.

Electrodeposited Coatings

Type ➡	Magnesium	Manganese	Molybdenum	Nickel	Palladium	Platinum
BASE METALS	(experimental)	Iron, aluminum, copper and its alloys	Zinc, cadmium	Most ferrous and nonferrous metals	Copper and its alloys	Lead, tin, zinc, white gold
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	91	—	83.8	34.4	40.6	40.2
Elec Res, microhm-cm	4.6	5	5.7	7.4–10.8	11	10
Color (natural)	White	Gray	Gray	Gray, white (bright)	Bright	Gray (bright)
Reflectance When Polished (5000 A), %	0.72	—	46	61	—	58
Melting Point, F	1204	2300	4748	2651	2820	3223
Min Thickness, mil	—	—	—	0.1	0.02	Flash
MECHANICAL PROPERTIES						
Brinell Hardness	—	—	—	150–500	—	—
Abrasion Resistance[a]	—	—	Excellent	Excellent	—	—
CORROSION RESISTANCE, 10^{-6} ipy						
Atmosphere	—	—	—	1–160	—	—
Sea Water	10,000–80,000	—	—	300–1000	—	—
SOLDERABILITY						
As Plated	—	—	—	Good	—	—
After 192-Hr Salt Spray	—	—	—	Poor	—	—
COST	—	—	—	Moderate	High	High
USES[b]	Experimental	Experimental	Experimental	C, D, E, R, W	c, D	c, D

Type ➡	Rhenium	Rhodium	Selenium	Silver	Tin	Titanium
BASE METALS	(experimental)	Most ferrous and nonferrous metals	(experimental)	Most ferrous and nonferrous metals	Most ferrous and nonferrous metals	Steel, nickel, copper
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	—	50.9	—	244	36.3	—
Elec Res, microhm-cm	21	4.7	12	1.6	11.5	3.2
Color (natural)	Gray (bright)	White (bright)	Gray	White (bright)	White	—
Reflectance When Polished (5000 A), %	—	76	—	91	—	—
Melting Point, F	5732	3553	423	1760	448	3272
Min Thickness, mil	—	0.001	—	0.1	0.015	—
MECHANICAL PROPERTIES						
Brinell Hardness	250	400–800	—	50–150	5	—
Abrasion Resistance[a]	Good	Excellent	—	Poor	Poor	—
CORROSION RESISTANCE, 10^{-6} ipy						
Atmosphere	—	—	—	—	72–320	—
Sea Water	—	—	—	40	30–90	—
SOLDERABILITY						
As Plated	—	—	—	—	Good	—
After 192-Hr Salt Spray	—	—	—	—	Poor	—
COST	—	Moderate	—	High	Moderate	—
USES[b]	d	c, D	Rectifiers	C, D, e, w	Experimental	Experimental

[a] Even though some electroplates abrade easily they may still have excellent appearance (e.g., gold and silver), or may even provide an excellent bearing surface (e.g., indium, silver and lead).

[b] Capital letter indicates frequent use, small letter infrequent. C = corrosion protection; D = decoration; E = electroforming; R = reclaiming; W = wear resistance.

continued on next page

Electrodeposited Coatings

Type ➡	Tungsten	Zinc	Zirconium	Cobalt-Nickel	Copper-Tin (bronze)	Copper-Zinc (brass)
BASE METALS	(experimental)	Ferrous metals	(experimental)	(experimental)	Steel, copper, brass, zinc	Iron, steel, aluminum, zinc
PHYSICAL PROPERTIES						
Ther Cond, Btu/hr/sq ft/°F/ft	84.7	64.2	—	—	—	—
Elec Res, microhm-cm	5.5	5.8	41	—	—	—
Color (natural)	Gray	White (bright)	—	Gray	Pink (bright)	Yellow (bright)
Reflectance When Polished (5000 A), %	0.49	55	—	—	—	—
Melting Point, F	6098	786	3452	—	—	—
Min Thickness, mil	—	0.15	—	—	0.5	0.1
MECHANICAL PROPERTIES						
Brinell Hardness	—	40–50	—	—	—	—
Abrasion Resistance[a]	—	Fair	—	Good	Good	Fair
CORROSION RESISTANCE, 10^{-6} ipy						
Atmosphere	—	8–210	—	—	—	—
Sea Water	—	1000–6000	—	—	—	—
SOLDERABILITY						
As Plated	Good	—	—	—	—	—
After 192-Hr Salt Spray	Poor	—	—	—	—	—
COST	—	Low	—	—	Moderate	Moderate
USES[b]	Experimental	C, d	Experimental	Magnetic	c, D, w	c, D

Type ➡	Lead-Tin	Nickel-Tin	Phosphorous-Nickel-Cobalt	Tin-Zinc	Tungsten-Nickel-Cobalt-Iron
BASE METALS	Steel, copper, brass	Most ferrous and nonferrous metals	—	Most ferrous and nonferrous metals	—
PHYSICAL PROPERTIES					
Ther Cond, Btu/hr/sq ft/°F/ft	—	—	—	—	—
Elec Res, microhm-cm	—	—	110–118	—	—
Color (natural)	White	White (bright)	Bluish (bright)	White	Gray
Reflectance When Polished (5000 A), %	—	15–118	—	—	—
Melting Point, F	—	—	—	—	—
Min Thickness, mil	0.2	0.5	—	0.15	—
MECHANICAL PROPERTIES					
Brinell Hardness	—	625 (Vickers)	—	—	—
Abrasion Resistance[a]	Poor	Good	—	Good	—
CORROSION RESISTANCE, 10^{-6} ipy					
Atmosphere	—	—	—	—	—
Sea Water	—	—	—	—	—
SOLDERABILITY					
As Plated	Good	—	—	Good	—
After 192-Hr Salt Spray	—	—	—	Poor	—
COST	Moderate	Moderate	—	Moderate	—
USES[b]	c, w	C, D	C, d, e, w	C	C, e, r, w

[a] Even though some electroplates abrade easily they may still have excellent appearance (e.g., gold and silver), or may even provide an excellent bearing surface (e.g., indium, silver and lead).

[b] Capital letter indicates frequent use, smaller letter infrequent. C = corrosion protection; D = decoration; E = electroforming; R = reclaiming; W = wear resistance.

Sprayed Metal Coatings

Type ➡	Aluminum	Babbitt A[a]	Brass (65:35)	Bronze AA[b]	Commercial Bronze	Manganese Bronze	Phosphor Bronze
Specific Gravity	2.41	6.67	7.45	7.06	7.57	7.26	7.68
Ult Ten Str, 1000 psi	19.5	—	12	29	11.5	12	18
Strain at Ult Str, %	0.23	—	0.45	0.46	0.42	0.46	0.35
Rockwell Hardness	H72	H58	B22	B78	B18	B27	B20
Shrinkage, in./in.	0.0068	—	0.009	0.0055	0.011	0.009	0.010
Spraying Speed, lb/hr	18	95	32	24	24	36	31
Spraying Efficiency, %[c]	89	69	81	77	82	79	85
Major Characteristics and Uses[d]	Good corrosion and heat resistance	Good bearing properties	Sprays fast. Fair machine finish	Hard, very wear resistant. Easily machined	Softest bronze. Fair machine finish	Excellent machine finish. Special uses only	Fair machine finish. Special uses only

[a] Lead-free, high tin alloy. [b] Aluminum-iron-bronze. [c] Percent of metal deposited.

[d] All metals have about the same shiny surface after spraying, but surfaces of the various metals differ after machining.

Type ➡	Tobin Bronze	Copper	Lead	Molybdenum	Monel	Nickel	18-8 Stainless
Specific Gravity	7.46	7.54	10.21	8.86	7.67	7.55	6.93
Ult Ten Str, psi	13	—	—	7.5	21	17.5	30
Strain at Ult Str, %	0.51	—	—	0.30	0.26	0.30	0.27
Rockwell Hardness	B27	B32	—	C38	B39	B49	B78
Shrinkage, in./in.	0.0104	—	—	0.003	0.009	0.008	0.012
Spraying Speed, lb/hr	36	29	80	8	17	18	21
Spraying Efficiency, %[c]	80	80	65	87	85	79	81
Major Characteristics and Uses[d]	General purpose. Fair machine finish	Electrical uses; brazing	Good corrosion resistance. X-ray shielding	Used as bonding coat. Excellent bearing properties	Good corrosion resistance. Good machine finish	Good corrosion resistance. Fair machine finish	High corrosion resistance. Good wearing properties

Type ➡	High Cr Stainless	Steel (LS)[e]	Steel (0.10% C)	Steel (0.25% C)	Steel (0.80% C)	Tin	Zinc
Specific Gravity	6.74	6.78	6.67	6.78	6.36	6.43	6.36
Ult Ten Str, psi	40	33.5	30	34.7	27.5	—	13
Strain at Ult Str, %	0.50	0.45	0.30	0.46	0.42	—	1.43
Rockwell Hardness	C29	C25	B89	B90	C36	—	H46
Shrinkage, in./in.	0.0018	0.002	0.008	0.006	0.0014	—	0.010
Spraying Speed, lb/hr	19	18	19	19	19	95	61
Spraying Efficiency, %[c]	81	87	87	87	87	73	66
Major Characteristics and Uses[d]	High hardness and wear resistance. Grind finish	Good mechanical and finishing properties	Simple bearing surfaces and press fits. Excellent machine finish	Harder and lower shrinkage than 0.10C. Excellent machine finish	Very hard and wear resistant. Good bearing properties. Grind finish	Good corrosion resistance, especially with foods	Good all-around corrosion resistance

[e] Low shrinkage.

Hot Dip Coatings

Hot dipping is a comparatively low cost process for producing protective coatings on inexpensive high strength metals, usually steel. The process is limited to about five basic coating materials.

Aluminum

Hot dipped aluminum coatings (aluminizing) on steel combine the corrosion resistance and heat reflectivity of aluminum with the mechanical and physical properties of steel. The coatings can be applied to steel sheet, strip or wire simply by passing the metal through a molten bath of aluminum alloy. The coatings are most commonly applied in thicknesses of 1 to 2 mils to mild steel and low alloy high strength steels.

The corrosion resistance of hot dipped aluminum coatings on steel is quite good, and in many cases is superior to galvanized steel. However, galvanized steel is less expensive. Hot dipped aluminum steel will withstand temperatures of about 900 F without discoloring, about 1250 F without descaling, and will even withstand temperatures up to 1650 F in some cases. Above 900 F the coating begins to alloy with the base metal and form a refractory layer which does not return to its original state upon cooling. The excellent heat resistance of the coating is combined with high thermal reflectivity—on the order of 80%.

Hot dipped aluminum steel is being used in a large number of high temperature applications such as airplane fire walls, water heater and oven liners, mufflers, heat exchanger tubes, space heater parts and combustion chambers.

Zinc

Because of its ideal combination of high corrosion protection and low cost, hot dipped zinc coatings (galvanized coatings) are widely used for the protection of steel products. After cleaning, the article to be coated is dipped in a bath of molten zinc. The resulting coating usually consists of an outer layer of relatively pure zinc and lower layer(s) of iron-zinc compounds.

The popularity of galvanized coatings on iron and steel stems from three important factors: 1) zinc has a slower rate of corrosion than iron, 2) zinc corrosion products are white and nonstaining, and 3) zinc affords electrolytic protection to iron. The protective value of galvanized zinc depends almost entirely on the thickness of the coating. For structural steel shapes, plates and bars, the weight of the coatings should be at least 2 oz per sq ft.

The life of zinc coatings may be five to ten times greater in rural atmospheres than in industrial atmospheres containing sulfur and acid gases. Nevertheless, the coatings still are quite popular for industrial use because of their very low cost. Some typical uses for the coatings are: roofing and siding, nails, wire, tanks, boilers, pails, and a wide range of hardware for indoor and outdoor use.

Lead

The primary advantage of hot dipped lead coatings on steel is their high resistance to chemicals and atmospheric corrosion. Hot dip lead coatings are resistant to many chemicals, such as sulfuric acid, hydrochloric acid and brine. Their high resistance to some types of atmospheric corrosion stems from the formation of a superficial oxide film which is relatively impervious to corrosion and which regenerates itself when damaged. This sulfate film is readily formed in industrial atmospheres, and for this reason lead coatings perform better in industrial than in rural areas.

Because of their softness, lead coatings can withstand severe deformation before damage becomes serious. This same softness also gives the coatings poor resistance to wear and abrasion. Poor adhesion may also be a problem since the bond produced is purely mechanical. However, this problem can be minimized by adding small quantities of alloying elements. Pinholes formed during application may be potential sources of corrosion but they can be eliminated by slight working or burnishing. Unfortunately, if corrosion does occur it usually occurs at the expense of the iron.

Hot dipped lead coatings have been satisfactorily used on such items as wire, pole-line hardware, bolts, washers, tanks, barrels, cans and air ducts. The excellent adhesion of organic coatings to lead-coated sheet has proved valuable in outdoor applications such as gutters, flashing and corrugated siding.

Tin

Hot dipped tin coatings are used to improve the corrosion resistance of steel and copper in sheet or fabricated form. Like zinc, hot dipped tin coatings consist of two layers—an outer layer of relatively pure tin, and an intermediate layer made up of an intermetallic compound of the base metal.

A short time after the coatings are exposed to air an invisible film of stannic oxide forms and helps to retard, but does not completely prevent, corrosion. Tin coatings have very good resistance to tarnishing and staining indoors. Their corrosion resistance in pure rural atmospheres is also quite good and is much better than in marine or industrial atmospheres. Corrosion resistance in all cases is markedly improved by increasing thickness and controlling porosity. Hot dipped tin contains many minute pores which cause accelerated corrosion, particularly in wet environments. The coatings resist foods.

Hot dipped tin sheet shows little damage when severely deformed. Thus, the sheet can be fabricated into a variety of parts by stamping, drawing, rolling, lock-seaming and bending. The sheet is also readily soldered.

Hot dipped tin coatings on food cans have largely been superseded by thin tin electroplates. However, the heavier coatings produced by hot dipping are needed for some fabricated articles and castings.

Lead-Tin

The composition of lead-tin or "terne" coatings can vary over a wide range; however, in most cases the coatings contain 20 to 25% tin and 80 to 75% lead. The main advantage of lead-tin coatings is that they provide some of the advantages of a tin coating, but at lower cost. The coatings are well suited for deep drawing operations because of their ductility and good adhesion.

Actually, lead-tin coatings only provide mechanical protection against corrosion. However, if used in sufficient thickness, the coatings can provide good protection, especially for gasoline tanks and roofing, and for benches and cabinets used in chemical laboratories. Lead-tin coatings have excellent paint holding properties, and their corrosion resistance can be improved greatly by using an organic coating.

Diffusion Coatings

A large number of elements can be diffused into the surface of metals to improve their hardness and resistance to wear, corrosion and oxidation. Diffusion coatings (sometimes called cementation coatings) are applied by heating the base metal in an atmosphere of the coating material, which diffuses into the metal.

Calorized

Aluminum (calorized) coatings are applied by diffusion to carbon and alloy steels to improve their resistance to high temperature oxidation. They can be applied by treating the metal in a powdered aluminum compound or in aluminum chloride vapor, or by spraying the aluminum on and subsequently heat treating it. The alloy coating formed (about 25% aluminum) protects the metal by sealing it from the surrounding air. The coatings range in depth from 5 to 40 mils and permit parts to remain serviceable for many years at temperatures up to 1400 F. They have also been used for intermittent exposure as high as 1700 F. Typical high temperature uses are chemical and metal processing pots, bolts, air heater tubes, and parts for furnaces, steam superheaters and oil and gas polymerizers.

Carburized

Carburizing allows steels to retain high internal strength and toughness and at the same time have high surface hardness. The hardened surface is produced by introducing carbon into a steel surface by heating the metal above the transformation temperature while it is in contact with a carbonaceous material which may be a solid, gas or liquid.

In general, carburizing is limited to steels low enough in carbon (below about 0.45%) to take up that element readily. Plain carbon steels are generally used if surface hardness is the principal requirement and core properties are not too critical. Alloy steels must usually be used if high strength and toughness are needed in the core. Typical applications are gears, cams, pawls, racks and shafts.

Chromized

Chromizing is the process of diffusing chromium into ferrous metals to improve their resistance to corrosion, heat and wear. Typical of the chromizing methods that have been developed is one in which the parts to be treated are packed in a proprietary powdered chromium compound and heated to 1500 to 1900 F. This method produces a high chromium-iron alloy on ferrous metals with a low carbon content. The case (3 mils thick) exhibits good resistance to scaling and corrosion at high temperatures. A chromium carbide case is produced on high carbon materials such as cast iron, iron powder, tool steel and plain carbon steels containing over 0.40% carbon. This case (½ to 2 mils thick) has a hardness of 1600 to 1800 VPN.

Cyanided, Carbonitrided

Both cyaniding and carbonitriding produce a hard and wear resistant surface on low carbon steels. Both methods cause carbon and nitrogen to diffuse into the surface of the base metal. The case developed has high hardness after quenching. The methods differ in that a liquid bath is used in cyaniding, whereas a gas atmosphere is used in carbonitriding.

In general, cyaniding and carbonitriding are used with the same base metals and for the same applications as carburizing. Warpage is usually less serious than in carburizing. Quenching is usually required for full hardness but file hardness can be obtained without quenching.

Nickel-Phosphorus Coated

With some exceptions, nickel-phosphorus coatings can be roughly classified as diffusion coatings. The coatings are prepared from nickel oxide, dibasic ammonium phosphate and water, and are applied to ferrous surfaces just like a paint. Subsequent heat treatment in a controlled atmosphere produces coatings with a degree of corrosion resistance approaching that of stainless steel and the high nickel alloys. The coatings have little porosity and high resistance to heat and abrasion.

Nitrided

Nitriding is a means of improving wear resistance. In the most widely used process, steel is exposed to gaseous ammonia at a temperature (about 1000 F) suitable for the formation of metallic nitrides. The hardest cases are obtained with aluminum-bearing steels such as the Nitralloys. Where lower hardness is acceptable, steels containing no aluminum, such as medium carbon steels containing chromium and molybdenum, can be used.

Stainless steels can also be case hardened by nitriding (e.g., Malcolmizing). Straight chromium steels are more readily nitrided than nickel-chromium steels, although both are used. Tool steels can also be given a thin hard case.

Nitriding produces minimum distortion. Some growth occurs, but this can be allowed for. In general, nitriding is used for the same applications as carburizing.

Sherardized

Sherardizing is the process of applying zinc coatings to ferrous and nonferrous metals to improve their corrosion resistance. The coatings are applied by heating parts in a zinc powder at 650 to 700 F for 3 to 12 hr.

Sherardized zinc coatings are not as protective as plated or hot dip zinc coatings; however, they can be applied in more uniform thicknesses. Ordinarily, they are quite satisfactory for mild atmospheres. Principal applications are small steel parts such as nuts, bolts and washers, or castings that must resist atmospheric corrosion.

Siliconized

Substantial improvements in the wear resistance and hardness of steel and iron parts can be obtained by impregnating with silicon (about 14%). The most wear resistant cases are formed on low carbon, low sulfur steels. High carbon, low sulfur steels can also be impregnated, although treatment time is longer. White and malleable iron can also be siliconized; siliconizing of gray irons is not recommended.

The case of a siliconized surface (about 5 to 10 mils) is rather brittle, hardness varying from Rockwell B80 to B85. Siliconized sufaces are virtually nongalling and are especially effective in resisting combined wear and corrosion.

Vapor Deposited Coatings

Coatings deposited on metals and nonmetallic materials by condensing a metallic vapor may be classified in three ways by the vapor source: 1) vacuum metallized—evaporation of molten metals, 2) cathode sputtered—voltage causes ion bombardment to vaporize metals, and 3) vapor plated—thermal reduction or decomposition of volatile compounds of the metal. All three require expensive vacuum equipment and methods of producing medium to high temperatures.

Vapor deposited coatings serve chiefly as decorative effects, but increasingly functional applications are being developed. Choice of the type of vapor coating depends upon: the metal to be deposited, the nature of the base material, the thickness and uniformity of the coating required, the size and shape of the part, and end-service conditions.

Vacuum Metallized Coatings

The most important commercially of the three, vacuum metallized coatings are applicable to most metals and nonmetallics. Although steel, zinc and plastics are the most common materials coated by this process, glass and paper are rapidly gaining acceptance.

Principle of the process is simple: the metal to be evaporated is brought into contact with a hot tungsten, molybdenum or platinum filament (or it may be electrically heated in a refractory crucible) in a vacuum of at least 10^{-4} mm Hg. The metal evaporates in 5 to 15 sec and condenses on all cool surfaces that lie on a straight path from the filament. Parts requiring coating on more than one side must be rotated. Coating of deep grooves, undercuts and interior surfaces is not practical.

Advantages and limitations. Deposition rates are slow in comparison to electroplating, and the process is more expensive unless restricted to large runs of small or medium-sized parts and to thin coatings. For this reason deposits are generally 0.003 to 0.005 mil thick, with 0.01 mil considered an upper limit. But for such films there is no better method, both from a cost standpoint and because vacuum metallizing allows finely controlled and uniform deposits which closely follow the contours of the base surface. Abrasion resistance is, of course, extremely low, and corrosion resistance is generally low except for aluminum and cadmium coatings.

Uses. Aluminum is easily deposited by vacuum metallizing and is a satisfactory coating for all decorative and many functional coatings. For these reasons it is the most important commercial coating. Additional protection is provided by a lacquer topcoat which can also give color to simulate other metals. In the case of plastics and porous materials an undercoat, usually an alkyd resin type, is baked on.

Aluminum-coated steel or zinc is used for such items as hardware, costume jewelry, optical reflectors, instrument parts, appliance trim and automotive interior hardware. Selenium-coated nickel-plated aluminum sheet is used in selenium rectifiers. Colored aluminum-coated textured steel and aluminum-coated wrinkle-finished die castings are imaginative uses.

Aluminum-coated plastics, particularly the thermosets, are finding wider use in the automotive industry for interior hardware, panels, dials and trim. Transparent acrylic parts coated on the back surface have been used for many years.

Electroluminescent panels consist of coated glass panels that have been metallized with an aluminum coating which serves the functional purpose of conductivity. Another functional application is the aluminum or cadmium metallizing of high tensile strength steels for corrosion resistance. Cadmium is the best here; electrolytic deposition causes embrittlement whereas metallizing is satisfactory. These coatings are 0.3 to 0.5 mil thick, and deposition requires 15 to 30 min.

Cathode Sputtered Coatings

These coatings have the advantage of requiring a lower vacuum (0.01 to 0.1 mm Hg), and thus need less expensive equipment than vacuum metallizing. However, deposition rates are slower and some metals, including aluminum, cannot be satisfactorily deposited.

The method involves applying a high voltage (10,000 v or more) across two electrodes and causing ion bombardment to vaporize the cathodic metal and deposit it as a crystalline fine-grained coating on material placed near the anode. Thin films are generally highly porous, but deposits of 0.04 mil are satisfactory.

Both metals and nonmetallics can be metallized by this method, but the temperature rise produced in a substrate may be greater than in vacuum metallizing and this may be a limiting factor in some cases. In addition it is difficult to obtain coatings free from oxide contamination unless all traces of oxygen are excluded from the sputtering atmosphere.

Low-vapor-pressure metals such as platinum and palladium are more easily deposited by sputtering than by other types of vapor deposition because of the high temperature sources the other methods require. Gold and silver are among those metals with the highest deposition rates.

Applications include phonograph recording masters, surgical gauze, broadcasting transmitters and jewelry.

Vapor Plated Coatings

These coatings can be obtained by the reduction or displacement of halides or by the thermal decomposition of halides. Of commercial importance is a variation of the thermal decomposition method termed "gas plating." The metal to be deposited must exist in the form of a gaseous compound which decomposes at a temperature higher than its vaporization temperature. The part to be plated is heated above the decomposition temperature and inserted in the plating chamber.

Most common of these required compounds are the carbonyls of nickel, iron, chromium, cobalt, molybdenum and some precious metals. However, extensive commercial work has been done only with nickel.

Advantages of the process include its adaptability to odd-shaped objects (metal is deposited equally well on all heated surfaces), speed of deposition (higher than in any conventional plating process), and the possibility of depositing mixtures of metals as alloys. Gas plating also has an advantage in plating such porous surfaces as powdered metal parts. Principal drawbacks are the high cost of the gaseous metal compounds and, in some cases, the toxic nature of the materials involved.

Applications include thick coatings of refractory metals on wires, nickel-coated gasoline fuel delivery nozzles, and the previously impossible coating of nylon and glass fibers.

Hard Facings

Hard facings (overlays applied by welding operations) are generally applied to surfaces which require high wear resistance. Service conditions which may be met, directly or indirectly, by hard facing include: abrasion (sliding or rolling), galling, impact, work hardening, elevated temperatures, thermal stresses, corrosion and erosion.

Types. Most hard facing alloys are proprietary alloys designed for special service conditions, but the basic types are summarized below. It can be misleading to group alloys by hardness or service use because it is primarily structure that determines their properties. Iron-base alloys, for example, can be austenitic, pearlitic, martensitic or a combination of these in the as-deposited, air cooled state. It is often difficult to determine what microstructure can be expected from a given rod.

Thickness. Thickness of hard facings ranges from 1/16 to ¼ in. depending upon the application. Parts that require a build-up greater than ¼ in. are usually given a primary layer with a lower cost material. Parts requiring extremely thin layers are generally hard faced with nickel-chomium-boron alloys which wet the base metal so readily that a uniform deposit 1/32 in. thick can be obtained.

Surface finish. Smoothness of a hard facing depends upon both material and application method. Nonferrous alloys, having more fluidity, yield the smoother deposits. Tungsten carbide rods produce a rough surface because the particles must be submerged in a matrix of softer material which wears away and exposes the rough carbide particles.

BASIS METALS FOR HARD FACING

Metal ↓	Suitability	Remarks
Low and Medium Carbon Steels	Up to 0.50 carbon steels particularly suitable	Pre- or post-heat treatment not required
High Carbon and Low Alloy Steels	Up to 1.10 carbon and 14 manganese steels are suitable if careful to prevent cracking	Annealed or as-rolled condition; generally post-heat treated
High Speed Steels	Not advisable; shrinkage cracks, strain checks	Annealed condition; post-heated and slowly cooled
High Chromium Steels	Susceptible to heat; require careful handling	Preheated to 1200 F; slow post-cooling
Manganese Steels	Difficult, due to heat disrupting grain structure. Arc welding best	Stainless steel often applied first as binding agent
Stainless Steels	Arc or gas method with care to avoid excessive strains	Parts should be preheated to temperature dependent on stainless type
Cast Irons	Difficult. White iron easy for small parts. Otherwise danger of localized overheating	Lower melting point than steel; crust forms on surface
Nonferrous Alloys	Not those with melting points below 2000 F	Monel is common and easiest; copper alloys difficult

TYPES OF HARD FACING ALLOYS

Type ➡	General Properties	Forms	How Applied	Typical Uses
FERROUS ALLOYS				
Hardenable. Carbon steels; low, medium and high alloy steels; high speed steels	Alloys are listed in order of increasing hardness, corrosion and impact resistance. Medium-high levels of hardness and impact resistance obtainable, but abrasion and corrosion resistance lower than in other types	Mild steel rod with alloys in flux-coating; particles in thin tubes	Arc welding (bare and flux-coated rods) or gas welding (bare rods)	Base for subsequent hard facing with other types (particularly for thick facings); rock and earth-handling equipment
Austenitic. Chromium and chromium-nickel steels; high manganese steels; high chromium irons; high alloy irons	Provide principally austenitic deposits (except some straight chromium steels) hardenable by cold work. Fair degree of hardness with good impact and abrasion resistance extending into elevated temperatures	Cast rods	Arc welding (bare and flux-coated rods) or gas welding (bare rods)	Crushing equipment; such earth-moving equipment as bucket lips, crusher rolls and muller tires; plowshares
NONFERROUS ALLOYS				
Cobalt-base. Medium carbon; high carbon	High corrosion resistance, good abrasion and impact resistance. Hardness less than high ferrous alloys but retained at elevated temperatures ("red hardness")	Solid rods cast in permanent or sand molds	Gas welding (use of torch is similar to brazing)	Valves, pump parts, dies; large areas where hairline cracks not permissible
Nickel-base. Nickel-chromium; nickel-chromium-tungsten molybdenum	Excellent heat and corrosion resistance, fair abrasion and impact resistance. Hardness is less than high ferrous alloys but retained at elevated temperatures ("red hardness")	Solid rods cast in permanent or sand molds	Gas welding (use of torch is similar to brazing)	Very thin sections; parts which must be hot formed or hot wiped; substitute for tungsten carbide rods
Intermetallics. Tungsten carbides; others	Maximum hardness with excellent resistance to impact and corrosion. Despite brittleness, carbides have excellent resistance to fracture when backed up with steel.	Cast rod; particles in thin tube; powder; inserts	Rods by gas or arc; powder by spraying; inserts by "puddling"	Oil well drilling tools; mill hammers, augers, dipper bucket teeth and lips, mixing plows

Organic Coatings[a]

Type ➡	Alkyd						Acrylic	Bituminous
	Alkyd	Alkyd-Amine	Alkyd-Phenolic	Alkyd-Silicone	Alkyd-Urea	Styrenated Alkyd		
CHEMICAL RESISTANCE								
Exterior Durability	E	E	E	E	E	G	E	E
Salt Spray	E	VG	E	E	G	G	E	E
Solvents—Alcohols	F	G	G	F	G	G	G	P
Solvents—Gasoline	G	E	E	E	E	E	G	P
Solvents—Hydrocarbons	G	E	E	P	E	E	F	P
Solvents—Esters, Ketones	P	P	F	P	P	P	P	P
Solvents—Chlorinated	P	P	F	P	P	P	P	P
Beverages, Food	F	G	VG	P	G	VG	VG	E
Salts	VG	E	E	F	E	E	VG	G
Ammonia	P	P	P	P	P	P	P	—
Alkalis[b]	G, G	VG, G	F, P	P, P	G, G	G VG	G, F	E
Acids—Mineral[c]	F, P, P	G, F, P	VG, G, F	G, P, P	F, P, P	G, F, P	G, F, P	G, —, —[j]
Acids—Oxidizing[c]	P, P, P	F, P, P	G, F, P	P, P, P	F, P, P	F, P, P	F, P, P	—
Acids—Organic (acetic, formic, etc.)[c]	P, P, P	P, P, P	F, P, P	P, P, P	P, P, P	P, P, P	P, P, P	E, —, —[k]
Acids—Organic (oleic, stearic, etc.)	F	G	VG	G	F	F	F	E
Acid—Phosphoric	P	P	P	P	P	P	P	E
Water (salt, fresh)	F	G	E	E	F	G	E	E
PHYSICAL PROPERTIES								
Sward Rocker Hard. (8th day)	24	30	34	16	28	28	24	—
Flexibility	E	VG	G	F	VG	G	E	E
Abrasion Res, cycles[d]	3500	>5000	>5000	1000	>5000	>5000	2500	—
Max Svc Temp, F	200	250	250	1000	225	200	180	325
Toxicity	None	Slight	None	Slight	Slight	Slight	None	—
Impact Res	VG	E	G	G	E	G	E	E
Dielec Properties	G	G	VG	E	G	G	VG	—
Adhesion to—								
Ferrous Metals	E	E	E	G	E	E	VG	E
Nonferrous Metals	F	E	E	F	VG	E	VG	E
Old Paints	VG	G	G	E	G	VG	P	—
DECORATIVE PROPERTIES								
Choice of Colors[e]	U	U	SL	U	U	U	U	L
Color Retention	G[f]	VG[f]	P[f]	E[f]	VG[f]	G[f]	E[f]	—
Initial Gloss	E	E	VG	E	E	E	E	P
Gloss Retention	E	G	F	E	F	G	E	—
APPLICATION								
Ease of Application	E	Bake req	E	E	Bake req	E	VG	P–VG
Metal Surface Prep	Primer	No primer	No primer	Primer	No primer	No primer	Primer	No primer
Solvent for Appl[g]	Hyd	Hyd	Hyd	Hyd	Hyd	Hyd	Blend	—
Methods[e]	U	U	U	U	U	U	U	L
Cure[h]	A or B	B	A or B	A or B	B	A or B	A	A
Bake Drying Time[i]	30 min (275 F)	20 min (320 F)	30 min (350 F)	30 min (350 F)	20 min (320 F)	15 min (300 F)	—	—
Air Drying Times								
Touch	2 hr	—	20 min	45 min	—	10 min	5 min	2 hr
Handle	4 hr	—	60 min	2 hr	—	30 min	15 min	24 hr
Re-Coat	4 hr	—	6 hr	4–6 hr	—	4 hr	15 min	—
Hard	12 hr	—	6 hr	12 hr	—	4 hr	12 hr	24 hr
Corr Res	48 hr	—	48 hr	12 hr	—	48 hr	24 hr	—
Coverage, sq ft/gal/mil	450	450	450	500	450	400	350	—
Coat Thk (avg), mil	1.5	1.5	1.5	0.6	1.5	1.5	1.0	3–250
Cost, ¢/sq ft/mil dry[l]	1.50	1.75	—	—	—	1.75	2.75	—

[a] These data are intended only as a preliminary selection guide. Final selections should be made after consulting with coating formulator. Key: E = excellent; VG = very good; G = good; F = fair; P = poor.

[b] Two ratings are for dilute (20%) and concentrated, respectively.

[c] Three ratings are for dilute (10%), medium (10–30%) and concentrated, respectively.

[d] Taber GS–10 wheel.

[e] L = limited (pure white cannot be formulated): SL = slightly limited (difficulty in formulating whites and pastels); U = unlimited (any color can be formulated).

Notes [f] through [l] on opposite page.

Organic Coatings [a]

Type ➡	Cellulose		Epoxy						Fluoro-carbon (air dried)
	Nitro-cellulose	Butyrate	Epoxy (100%)	Epoxy-Amine	Epoxy-Ester	Epoxy-Melamine	Epoxy-Phenolic	Epoxy-Urea	
CHEMICAL RESISTANCE									
Exterior Durability	E	E	G	E	G	E	E	G	E
Salt Spray	E	E	E	VG	E	VG	VG	VG	E
Solvents—Alcohols	G	G	E	E	VG	E	E	E	F
Solvents—Gasoline	G	G	E	E	E	E	E	E	F
Solvents—Hydrocarbons	F	F	E	E	VG	E	E	E	P
Solvents—Esters, Ketones	P	P	F	VG	F	VG	E	VG	P
Solvents—Chlorinated	P	P	E	E	F	E	E	E	P
Beverages, Food	P	G	E	E	VG	E	E	E	E
Salts	G	VG	E	E	E	E	E	E	E
Ammonia	P	P	P	P	P	P	VG	P	E
Alkalis[b]	P, P	P, P	E, E	E, E	E, E	E, E	E, E	E, E	E, E
Acids—Mineral[c]	G, F, P	G, F, P	E, VG, G	E, VG, G	G, F, P	E, VG, G	E, E, E	E, VG, F	E, E, E
Acids—Oxidizing[c]	P, P, P	P, P, P	G, P, P	G, P, P	F, P, P	G, P, P	E, VG, P	F, P, P	E, E, E
Acids—Organic (acetic, formic, etc.)[c]	P, P, P	P, P, P	G, F, P	G, F, P	F, P, P	G, F, P	E, E, VG	F, P, P	E, E, E
Acids—Organic (oleic, stearic, etc.)	F	F	E	E	E	E	E	E	E
Acid—Phosphoric	P	P	P	P	P	P	E	P	E
Water (salt, fresh)	F	E	VG	G	VG	G	E	G	E
PHYSICAL PROPERTIES									
Sward Rocker Hard. (8th day)	26	26	36	36	30	36	44	34	20
Flexibility	E	E	E	G	G	VG	VG, E	VG	G
Abrasion Res, cycles[d]	2500	2500	>5000	>5000	>5000	>5000	>5000	>5000	1000
Max Svc Temp, F	180	180	400	400	300	400	400	400	—
Toxicity	None	None	Slight	Slight	Slight	Slight	Slight	Slight	Slight
Impact Res	E	E	G	G	E	G	G	G	E
Dielec Properties	P	G	VG	VG	VG	VG	VG	VG	E
Adhesion to—									
Ferrous Metals	VG	VG	E	E	E	E	E	E	VG
Nonferrous Metals	G	G	E	E	VG	E	E	E	VG
Old Paints	P	P	P	P	F	P	P	P	P
DECORATIVE PROPERTIES									
Choice of Colors[e]	U	U	SL	SL	SL	SL	L	SL	U
Color Retention	E[f]	E[f]	G[f]	G[f]	E[f]	G[f]	P[f]	G[f]	G
Initial Gloss	E	E	VG	VG	E	VG	VG	VG	E
Gloss Retention	VG	E	F	F	G	F	F	F	F
APPLICATION									
Ease of Application	VG	VG	Catalyst req	Catalyst req	E	Bake req	Bake req	Bake req	VG
Metal Surface Prep	Primer	Primer	No primer	No primer	Primer	No primer	No primer	No primer	Primer
Solvent for Appl[g]	Blend	Blend	Ketone	Blend	Hyd	Blend	Blend	Blend	Blend
Methods[e]	U	U	L	L	U	L	L	L	L
Cure[h]	A	A	A	A	A or B	B	B	B	A or B
Bake Drying Time[i]	—	—	—	—	30 min (320 F)	30 min (350 F)	30 min (400 F)	30 min (350 F)	—
Air Drying Times									
Touch	5 min	5 min	45 min	45 min	1 hr	—	—	—	5 min
Handle	15 min	15 min	2 hr	2 hr	2 hr	—	—	—	15 min
Re-Coat	15 min	15 min	6–8 hr	6–8 hr	8 hr	—	—	—	12 hr
Hard	12 hr	12 hr	12 hr	12 hr	8 hr	—	—	—	12 hr
Corr Res	24 hr	24 hr	7–10 days	7–10 days	5 days	—	—	—	12 hr
Coverage, sq ft/gal/mil	200	200	450	500	450	500	450	500	200
Coat Thk (avg), mil	1.0	1.0	1.8	1.8	1.5	1.8	1.8	1.8	1.0
Cost, ¢/sq ft/mil dry[l]	2.50	2.75	—	—	1.75	—	—	2.00	15.00

Notes [a] through [e] on opposite page.

[f] Based on white coatings with titanium dioxide pigment. [g] Hyd = hydrocarbons; alc = alcohols.

[h] A = can be air dried; B = can be baked. In general, any coating that can be air dried or baked will perform better if baked.

[i] Full corrosion resistance is obtained, immediately upon cooling. [j] Not recommended with nitric acid.

[k] Not recommended with strong solutions of acetic acid.

[l] Based on high quality formulations; figures are meant to serve only as a rough guide.

continued on next page

Organic Coatings[a]

Type ➡	Phenolic	Poly-amide (nylon)	Rubber			Silicone	Urethane	Vinyl[f]	Vinyl-Alkyd (approx 1:1)
			Chlorinated Rubber	Neoprene	Hypalon				
CHEMICAL RESISTANCE									
Exterior Durability	E	P	E	E	E	E	E	E	E
Salt Spray	E	F	E	E	E	E	E	E	E
Solvents—Alcohols	E	G	F	E	—	P	F–G	E	G
Solvents—Gasoline	E	G	G	F	P	VG	F–G	E	E
Solvents—Hydrocarbons	E	—	P	P	—	VG	F–E	G	P
Solvents—Esters, Ketones	E	—	P	G	—	P	F	P	P
Solvents—Chlorinated	G	—	P	P	—	P	P	P	P
Beverages, Food	E	—	G	F	—	P	VG	E	F
Salts	E	—	E	E	—	G	E	E	G
Ammonia	P	G	VG	E	E	P	P	E	P
Alkalis[b]	P, P	G, G	VG, F	E, E	—	P, P	VG, F	E, E	G, P
Acids—Mineral[c]	E, E, E	P, P, P	E, G, P	E, G, P[k]	E, E, E	G, P, P	G, F, P	E, E, G	VG, G, P
Acids—Oxidizing[c]	E, E, VG	—	E, E, P	G, F, P	—	P, P, P	G, F, P	E, VG, G	P, P, P
Acids—Organic (acetic, formic, etc.)[c]	G, F, P	P, P, P	G, P, P	P, P, P	—	P, P, P	G, F, P	E, P, P	G, F, P
Acids—Organic (oleic, stearic, etc.)	E	VG	E	F	—	P	F	E	E
Acid—Phosphoric	F	—	G	VG	E	P	F	E	F
Water (salt, fresh)	E	F	VG	E	E	E	E	E	E
PHYSICAL PROPERTIES									
Sward Rocker Hard. (8th day)	38	—	24	<10	—	16	35–65	20	26
Flexibility	G	G	VG	E	E	F	E	E	E
Abrasion Res, cycles[d]	>5000	—	>5000	5000	—	2500	>5000	>5000	2500
Max Svc Temp, F	350	300	250	200	250	1200	300	180	180
Toxicity	None	—	Slight	None	—	Slight	Slight	None	None
Impact Res	G	VG	G	E	E	G	E	E	E
Dielec Properties	E	G	E	F	VG	E	E	E	G
Adhesion to—									
Ferrous Metals	E	VG	F	VG	VG	G	E	VG	VG
Nonferrous Metals	E	VG	VG	VG	VG	F	E	VG	G
Old Paints	G	—	E	—	—	E	F	G	P
DECORATIVE PROPERTIES									
Choice of Colors[e]	L	L	L	L	U	U	U	U	U
Color Retention	P[f]	—	G[f]	G	E	G[f]	G	VG[f]	E[f]
Initial Gloss	VG	G	F	P	P	E	E	G	E
Gloss Retention	F	—	F	F	—	E	P	F	E
APPLICATION									
Ease of Application	E	G	E	VG	VG	E	E	VG	VG
Metal Surface Prep	No primer	No primer	Primer	No primer	No primer	Primer	Primer	Primer	Primer
Solvent for Appl[g]	Alc	—	Hyd	Hyd	Hyd	Hyd	Blend	Blend	Blend
Methods[e]	U	L	U	U	U	U	U	L	U
Cure[h]	A or B	A	A or B	A or B	A	A or B	A or B	A or B	A
Bake Drying Time[i]	30 min (350 F)	—	15 min (300 F)	15 min (300 F)	—	1 hr (400 F)	30 min (325 F)	15 min (300 F)	—
Air Drying Times									
Touch	10 min	—	45 min	15 min	15 min	45 min	45 min	15 min	5 min
Handle	30 min	—	2 hr	30 min	30 min	2 hr	1–2 hr	30 min	15 min
Re-Coat	30 min	—	4–6 hr	4 hr	4 hr	4–6 hr	4–6 hr	4–6 hr	15 min
Hard	4 hr	—	4–6 hr	4 hr	4 hr	12 hr	18 hr	4–6 hr	12 hr
Corr Res	24 hr	—	24 hr	7–10 days	7–10 days	12 hr	5–7 days	24 hr	24 hr
Coverage, sq ft/gal/mil	350	—	450	300–400	250–350	350	—	250	200
Coat Thk (avg), mil	1.5	2–30	1.5	2–10	2	1.0	1–2	1.0	1.0
Cost, ¢/sq ft/mil dry[l]	1.75	—	1.50	—	—	6.00	—	2.50	—

Notes: See previous two pages.

Ceramic, Cermet and Refractory Coatings

Type ↓	Important Properties
Mixtures of Porcelain Enamel Frits and Refractory Materials	
NBS[a] A-19	Prevents oxidation of noncritical steels at high temp. Protects low carbon steel to 1250 F and high temp austenitic alloys to 1550 F
NBS A-31	Similar to A-19 coating but, since it must be applied in two coats, is only used for specialized applications
NBS A-417	Protects noncritical steels against high temp oxidation. Has been largely supplanted by A-418 coating
NBS A-418	Widely used to extend life of heat resisting steels such as Inconel, Inconel X, Nimonic 75, HS-21 and 18-8, 19-9 and 25-20 stainless steels. Protects up to 1750 F. Not recommended for low carbon steels
NBS N-143	Has low absorption coefficient for thermal neutrons and is designed for nuclear applications. Protects 310 stainless, Nichrome V and Inconel against oxidation up to 2050 F
Proprietary Coatings for:[b]	
Low Carbon and Low Alloy Steels	Improves oxidation and corrosion resistance to 1400 F
300 and 400 Stainless Steels	Extends service life of most alloys up to 1800 F. Special formulations protect against unusual abrasive or corrosive attack up to 2000 F
Aluminum	Extends operating temp of standard and some high strength alloys up to 1550 F
Titanium	Allows use of titanium up to 1500 F
Thin-Gage Metals	Protects foils 1 to 10 mils thick at temp up to 1750 F. Used on 300 and 400 stainless steels and superalloys
Extra High Temperatures	Special coatings for use up to 2100 F. Can be used on all alloys containing 45% of the combination of chromium (10% min), cobalt and nickel
Resistance to Galling	Provides low friction and prevents galling at temp from 800 to 1650 F. Can be used on all ferrous (and some nonferrous) alloys
Pure Refractory Oxide Coatings	
Aluminum Oxide (Alumina)	Provides high resistance to wear and abrasion, good thermal insulation, and high resistance to oxidation (3600 F melting point). Can be applied by variety of methods (e.g., flame spraying, Flame-Plating and plasma jet) to almost every ferrous and nonferrous metal, as well as some plastics and other nonmetallic materials
Zirconium Oxide (Zirconia)	Because of higher melting point (4500 F) can be used at higher temp than alumina. However, is not as hard or as resistant to abrasion as alumina. Can be used on same materials as alumina
Cermet Coatings[c]	
Aluminum-Ceramic	Composed of a mixture of aluminum alloy powder and ceramic frits. Can be applied to carbon steels, low alloys and cast iron for oxidation protection to 1200 F. Has high resistance to thermal shock and impact
Chromium Carbide (flame sprayed)	High resistance to abrasion and oxidation up to 2900 F. Can be ground to smooth finish
Chromium Carbide (chromized)	Provides hard and wear resistant case on low carbon steels, many alloy and high chromium steels, and iron powder parts
Chromium-Nickel Boride	Protects iron and steel against attack by molten aluminum. Good resistance to thermal shock
Molybdenum Disilicide	Provides good oxidation resistance to 2900 F. Coating is brittle but this may not be important in nonstructural uses
Nitrided Surfaces	Essentially, nitriding provides a cermet coating. Process is limited to certain grades of steel and forms an extremely hard case which retains hardness up to 1100 F and is not subject to fatigue
Silicon Carbide	Improves erosion resistance of graphite up to 4000 F. Highly resistant to acids and alkalis
Tungsten-Carbon and Tungsten-Boron	High density (0.53 lb per cu in.) is useful in increasing weight in restricted places
Tungsten Carbide	Provides extreme hardness and wear resistance. Can be applied to almost all metals
Other Refractory Coatings[d]	
Aluminum Silicate (mullite)	Protective coating for graphite
Iron Titanate	Similar to titanium dioxide in properties, but coating is softer and hence less useful
Iron Titanate: Gamma Aluminum (50:50)	Coating is conductive and has melting point of 2500 F. Not widely used
Titanium Dioxide	Provides hardness and wear resistance. Coating is tough, has excellent adhesion and is not brittle
Zirconium Silicate	Provides high hardness and resistance to wear, corrosion and thermal shock. Coating is nonconductive and has good adhesion

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[a] National Bureau of Standards.

[b] Many of these coatings are variations of NBS coatings. Coatings described are typical; many others are available for other base metals and special applications.

[c] In addition to the coatings described, recent announcement has been made of a number of other cermet coatings which can be applied by the plasma jet process. These coatings include refractory carbides of columbium, hafnium, tantalum, zirconium, titanium and vanadium. As of spring, 1959, these coatings are still largely in the experimental stage and little information is available on properties and applications. Molybdenum aluminide and nickel aluminide cermet coatings and rare earth (50% cerium oxide) refractory coatings can be applied by flame spraying but they do not appear to have any useful properties.

[d] In addition to the coatings described, a number of other refractory coatings can now be applied by the plasma jet process. These coatings are still experimental and property data is not yet available. The coatings encompass a wide variety of materials, including: 1) refractory oxides of thorium, hafnium, magnesium and cerium; 2) refractory metal compounds, such as borides of zirconium, tungsten, columbium, tantalum, titanium and chromium; 3) refractory metals, such as tungsten, tantalum, molybdenum and rhenium.

Porcelain Enamels

Composition

Porcelain enamel coatings are formulated for specific applications. They consist essentially of oxide color pigments, opacifiers and fluxes colloidally dispersed in fused silicates. They are smooth, hard and lustrous, and resist temperatures as high as 1000 F (except on aluminum). They may be formulated to provide an attractive, easily cleaned, durable finish; a chemical resistant barrier; or a wear resistant surface.

The enamels generally comprise one, two or three layers. The first layer on ferrous metals is usually a 3 to 4-mil "ground coat" (analogous to an organic primer) containing an oxide of cobalt, nickel or molybdenum that promotes good adhesion with the base metal. Where appearance is not important a ground coat may be used alone; but ordinarily it is followed by one or two 3 to 4-mil top coats, depending on the thickness required to achieve the desired opacity or protection.

Two general types of porcelain enamel frits are most widely used. Titanium types—so called because titanium dioxide is the opacifier—are preferred for white coatings because of their high covering power which makes necessary only a single 3 to 4-mil top coat. These relatively thin coatings (about 7 mils with a ground coat) have good acid resistance; good abrasion resistance; and good resistance to chipping during shearing, bending, punching and other fabricating operations. Titanium coatings can also be used for light or pastel colors, but where deep, bright colors are desired, acid resistant antimony type coatings are used. These coatings do not have the covering power of titanium types and require two 3 to 4-mil top coats for good appearance. They are also less abrasion resistant than titanium types.

Frits for aluminum and aluminized steel contain lead and are softer than conventional enamels. Lead-free frits are undergoing field tests.

Base Metals

Enameling iron. Ingot iron specially made for enameling. Produced in several grades suitable for various degrees of drawing or spinning. Good resistance to sagging and warping during firing. Produces minimum of surface defects in enamel.

Mild steel. Open hearth rimmed steel sheets such as AISI 1008 and 1010. Available in drawing quality grade. Likely to produce surface defects in enamel. Poor resistance to sagging and warping during firing.

Titanium enameling steel. Basic open hearth steel containing enough titanium to combine with and stabilize the carbon. Better drawing quality than enameling iron but somewhat inferior to the best deep drawn grades of mild steel. Yield strength comparable to that of enameling iron. Excellent sag resistance. Can be coated directly with white cover-coat enamels, making possible thin coatings. Expensive and somewhat limited in supply.

Cast iron. Typical satisfactory composition: 2.50 silicon, 0.70 phosphorus, 0.60 manganese, 0.08 sulfur, 3.00 free carbon and 0.40% combined carbon. Must have reasonably dense and uniform structure and be free from porosity, slag inclusions and segregation. Should be capable of developing a fairly smooth surface when sandblasted.

Aluminum. Includes wrought 1100, 3003, 6053 and 6061, and cast 43. Used for light weight, workability and resistance to edge corrosion. Can be cut without spalling after enameling. Requires prior surface treatment.

Aluminized steel. Combines strength, rigidity and sag resistance of steel with much of the workability and corrosion resistance of enameled aluminum. Requires no prior surface treatment.

Stainless steel. Not commercially important at present, but promising because of its corrosion resistance and the fact that, unlike aluminum, stainless enameled on only one side does not require straightening after firing.

Appearance

Color. Strongest, brightest colors are obtained in clear glasses, and some desirable colors such as the cadmium-selenium reds and oranges and the cadmium yellows can be obtained only in clear glasses. Moderately strong to bright colors can be obtained with semi-opaque antimony and zirconium frits.

Light to moderately strong colors are obtained with reduced opacity or "semi-opaque" titanium frits. Most stable colors are ivory-yellow, yellow, yellow-brown and blue-green; however, pink, gray and other popular decorator colors are currently in production even though some, notably pink, require very expensive raw materials. Semi-opaque enamels are applied about 20% thicker than standard white enamels. Weak or light pastel colors can be obtained with opaque titanium frits. Crimson to purple range of colors is still virtually impossible to obtain satisfactorily.

Metallic finishes such as copper, bronze, gold and gunmetal can be produced by some enamelers. Speckled finishes, once limited to white on dark blue or black, are now available in a greater variety of colors and designs. A wide range of luminescent colors that glow in ultraviolet light can be produced.

Precolored frits, once available only in intense blues and blacks, are now available in blue-green and in several lighter colors.

Pattern. Available in wood grain and marble-like patterns, in speckled designs, and in various other novelty patterns.

Texture. Ranges from extremely high gloss to a dull, full matte. Both glossy and matte finishes can be obtained in colors.

Opacity. Varies with color. White enamels usually require reflectance of 70 to 80% for satisfactory hiding power.

Thickness

The conventional porcelain enamel coating on steel consists of a ground coat and a cover coat having a total thickness of 7-8 mils. Enamel coatings on heavy castings are sometimes much thicker (up to 25 mils). Thinner coatings can be achieved by using special enamels, special base metals, or special surface treatments prior to enameling. For example, single coats of 3-4 mils are used on aluminum and aluminized steel. Titanium-bearing steel requires only a single coat. Some of the low firing enamels (i.e., enamels fired at temperatures as low as 1250 F) can be applied in a single coat. Promising surface treatments include application of a phosphate coating, and etching or blasting followed by electroless nickel plating.

Application Methods

Porcelain enamel coatings are applied by hand spraying, hand dipping, automatic spraying, automatic dipping and flow coating.

Automatic spraying provides more uniform coatings than hand spraying, reducing the amount of enamel needed to insure a specified minimum thickness. Electrostatic spraying reduces overspraying, producing potentially significant materials savings, particularly where expensive colored enamels are used.

Mechanized dipping, relatively new, is more adaptable to complex parts than automatic spraying. Flow coating is particularly advantageous for large cylindrical parts. Flow coated enamels are thinner at the top of the part and are prone to drain streaks.

Firing temperatures of ground coats range from 1600 to 1700 F. Firing temperatures of conventional cover coats on steel range from 1350 to 1500 F. Some of the new low firing enamels mature at temperatures as low as 1250 F. Enamels for aluminum are fired at about 1000 F.

Chemical Resistance

Acid resistance at room temperature. Enamels are rated AA, A, B, C or D, depending on their performance in the standard PEI T-7 or ASTM C 282 test. An enamel surface is exposed to a 10% solution of citric acid for 15 min at 80 F. The enamel is rated according to the appearance of the attacked area and the extent to which it retains a soil. Enamels with an acid resistance rating of A or above are usually specified where acid resistance is required.

Boiling acid resistance. Measured as weight loss of specimen exposed to boiling 6% solution of citric acid for 2½ hr (ASTM C 283).

Weathering resistance. Porcelain enamels that have acid resistance of at least Class B are usually able to withstand weathering for many years without becoming objectionably faded or etched. Enamels of less than Class B acid resistance usually exhibit poor weathering resistance. Certain AA acid resistance enamels containing a cadmium-selenium pigment appear to have poor weathering resistance.

Alkali resistance. Enamels with good alkali resistance are available. No standard test exists, but a test widely used consists of measuring the loss in weight and gloss after exposure to a hot sodium pyrophosphate solution.

Physical and Mechanical Properties

Abrasion resistance. Porcelain enamels combine a Mohs hardness of 4 to 6 with an exceptionally smooth surface, resulting in good resistance to scratching and abrasion. Abrasion resistance of a porcelain enamel is determined by abrading a specimen for a given time with an abrasive charge of grit, steel balls and water.

Surface abrasion resistance is an index of enamel's ability to retain its appearance after being subjected to abrasion at or near the surface. Index is percentage of original gloss retained after specimen has been abraded for about 5 min (PEI T-2).

Subsurface abrasion resistance is index of enamel's ability to protect underlying metal from exposure. Index consists of rate of weight loss over three successive 15-min abrasion periods (PEI T-2).

Torsion resistance. Torsion resistance is better in softer enamels and thinner coatings. It is determined by twisting enameled metal angle until enamel fails along apex. Angle of twist at which failure occurs is index of resistance to torsion (PEI T-5).

Adherence. Ability of enamel to protect base metal after it has been exposed to deformation is measured by adherence index. Index is determined by deforming an enameled metal specimen, then measuring relative areas of exposed metal and adhering enamel (PEI T-17, ASTM C 313).

Thermal shock resistance. Porcelain enamels do not normally fail from thermal shock unless they are cooled very rapidly from a high temperature. Coatings quenched with water may crack or spall. Thin coatings stand up much better than thick coatings. A standard test is under consideration by PEI, and a standard test for enameled kitchenware has been adopted by ASTM.

Thermal expansion. Thermal coefficient of expansion of an enamel should be such that from the firing temperature to the temperature of solidification no undue strains are set up between coating and base metal. In general, coefficient of expansion of enamels for flatware should be slightly greater than that of the base metal, and coefficient of enamels for cast iron should be close to that of the casting.

Heat resistance. Most enamels soften at about their firing temperature, but limiting service temperature is considerably lower and ranges from about 600 to 1000 F, depending on the application. In some cases service temperatures are limited by local strains set up as a result of differences in thermal expansion.

Mechanical Finishes for Aluminum, Copper and Stainless Steel[a]

Type ⬇	Appearance	How Finish Is Obtained[b,c]	Uses
Smooth Bright (buffed)	Brightest mechanical finish. Surface is smooth and lustrous, can be made mirror-bright by using fine abrasive, electro-brightening in final polishing, or (on aluminum) by electro-brightening or chemical brightening. Copper must be plated or clear-lacquered to preserve appearance	Two or three buffing operations (with progressively softer buffs and/or finer compound) following polishing or other finishing operations. Skilled operator needed to prevent buff-burned or pitted surfaces. Approx buffing wheel speeds: stainless 10,000; Al 8000; Cu 6–10,000 sfpm. Aluminum usually given light caustic etch between buffing steps to remove embedded particles	For attractive appearance or high reflectivity. Usually economically feasible only for larger items or close tolerance parts. Examples: household appliances, sanitary equipment, auto and boat trim, light reflectors, jewelry, small objets d'art. Also for Al before anodizing
Smooth Bright (burnished)	Not as bright as buffed surface esp if surface has retained oxide coating or has not been machined. Brightness dependent on time of treatment and relative movement and pressure of burnishing media	Relatively gentle tumbling in barrel with stainless steel balls 1/16–½ in. in dia and neutral soap solution (+soap bark for Cu).[d] Time required: stainless, 1–4; Al, 1½–2½; Cu, 6–48 hr. Hard to get uniform finish on complex-shaped parts	Similar to above, but generally smaller, mass-produced parts or parts difficult to buff. Examples: pen points, eyelets, grommets, auto trunk locks, auto pushbuttons
Satin Semi-Bright (wheel or belt polished)	Smoothest sheen of the satin finishes because of the finer, more irregular scratches. Brightness dependent on fineness of abrasive in final operation	Several polishing operations following grinding.[e] Wheels may be fabric, felt or leather; Tampico brush wheels may also be used, producing slightly duller surface. Lubrication usually required in wheel polishing with finer abrasives; belts reduce danger of overheating. Approx speeds: stainless 4500–7500, Al 5–6000, Cu 6–9000 sfpm. Abrasive usually alumina or silicon carbide (neither emery nor silicon carbide recommended for stainless). Preliminary polishing of Cu often done by sand-bobbing (using abrasive and wheel wet with mineral oil)	For parts where attractive, low reflection finish is desired. Examples: dairy, bar and cafeteria equipment; utensils; auto and furniture handles, knobs, rosettes. Also to prepare for finer finishes
Satin Semi-Bright (wire brushed)	Smooth sheen; smoothness dependent on wire size. Usually brighter than satin finish produced by polishing	Wire brushing of low polished surface entirely free of grease or oil. Brushes for Cu: brass, nickel silver or steel. Brushes for Al: stainless steel, brass, nickel or german silver (stainless preferred to avoid corrosion resulting from embedded particles). Brushes usually 10 in. in dia; wires range from 0.015 in. down to 0.002 in. for smoothest finish. Low pressures used. Wheel speeds range from 2000 rpm for polished sheet to 600 rpm for castings (castings are usually dustblasted or medium sandblasted before brushing). Nitric acid dip may be used after brushing to dissolve embedded particles	Same as above. Widely used on Al, sometimes on Cu. Not used on stainless because of its hard surface
Textured Semi-Bright (hammered)	Decorative finish somewhat similar to wrought silver. Minor scratches and defects obscured	Hammering by hand—the simplest mechanical finish. Parts may be heated in smoky fire and hammered until soot is embedded; polishing of high spots then produces special decorative effect	Used on Al and Cu. Examples: architectural and commercial products, giftware, novelty items
Textured Semi-Bright or Matte (embossed or engraved)	Patterned finish having wide variety of decorative effects	Sheet is passed between embossing rolls or pantograph-engraved; recesses may be filled with enamel for contrast and decoration. Applied to polished, buffed, satin finished, sandblasted (Al) or vapor honed (stainless) surfaces	Decoration and increase in rigidity. Limited to flat work. Examples: building panels, doors, nonskid surfaces, auto trim, plaques, tablets, nameplates
Textured Matte (sandblasted)	Special decorative effects esp by combination with other processes. Surface texture depends on size and type of abrasive, amount of air pressure, and movement and angle of nozzle. Surface collects dirt unless protected, as by clear lacquer	Spraying surface with fine abrasive or slurry by air pressure. Careful control of nozzle is needed for desired effects and to prevent distortion. Contrasting surfaces obtained by enameling, anodizing, blackening, highspot polishing, caustic etching, etc.	Primarily for aluminum.[f] Examples similar to above; not limited to flat pieces

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[a] Including aluminum and copper alloys.

[b] Stainless steel can be purchased with a number of different mill finishes. The bright cold rolled finish is usually specified for subsequent polishing or buffing. If severe forming is to be done, dull cold rolled may be preferable. Higher mill finishes available include polished. Tampico brush-finished and semi-mirror-finished.

[c] Aluminum mill finishes include a variety of embossed designs and a fluted finish.

[d] Another tumbling process—with granite chips, alumina or silica sand—is used to deburr and smooth stainless and aluminum parts, but does not produce as bright a surface and is not recommended for close tolerance parts.

[e] On aluminum, a somewhat brighter surface can be obtained by further finishing with steel wool and kerosene; a somewhat duller surface by low or coarse polishing followed by rubbing with steel wool and soapy water.

[f] Special effects on copper often achieved by engine turning. Stainless is usually vapor honed.

Hard Coatings and Surfaces

Type ↓	Method of Application	Basic Metals That Can Be Coated	Nature of Hard Surface	Usual Thickness Range	Hardness	Major Characteristics
Hard Facing	Hard alloys applied by variety of welding processes, including gas metal arc and atomic hydrogen arc. Surface of metal brought to melting point of hard facing alloy. Parts may require preheat at 700–1200 F	Practically all ferrous metals. Some high-melting nonferrous alloys	Variety of ferrous and nonferrous alloys	1/16–¼ in.	Wide range up to Rockwell A90, depending on alloy used	High hardness combined with varying degrees of resistance to abrasion impact, corrosion and heat, depending on alloy used
Carburized Surface	Carbon in solid, liquid or gas form introduced into metal surface by heating both in contact at temperatures above transformation range, generally 1450–1750 F	Carbon and alloy steels low enough in carbon content ($<0.45\%$) to take up that element readily	Case high in carbon	0.005–0.25 in.	Approx Rockwell C62–64	High strength and toughness in core can be combined with extreme surface hardness
Nitrided Surface	Nitrogen introduced into surface by heating metal in contact with ammonia or other nitrogeneous material at 930–1050 F	Primarily special nitriding steels. Also medium carbon steels containing chromium and molybdenum, stainless steels, some cast irons	Case containing nitrides of various alloying elements	0.005–0.030 in.	Approx Rockwell C63–64 for molybdenum steel; 15N92 for 416 stainless and Nitralloy 135	High wear resistance, retention of hardness at elevated temperatures. Good resistance to certain types of corrosion
Cyanided or Carbonitrided Surface	Carbon and nitrogen introduced into surface by heating metal in liquid cyanide (cyaniding) or in carbonaceous and nitrogeneous (carbonitriding) both at 1200–1600 F	Same steels as used for carburizing	High carbon case containing nitrides	0.003–0.020 in.	Rockwell A80–81 for SAE 1010 steel	In general, same as for carburized cases
Siliconized Surface	Silicon introduced into surface by heating metal in contact with silicon carbide and chlorine at 1700–1850F	Low carbon($<0.25\%$), low sulfur ($<0.04\%$) steels	Alloy case containing up to 14% silicon	0.005–0.010 in.	Rockwell B80–85	High resistance to wear, heat, corrosion
Chromized Surface	Chromium introduced into surface by heating metal in contact with chromium-containing powdered compound at 1500–1900 F	Low and high carbon steels, many alloy steels, stainless steels, tool steels, cast iron, iron powder parts	High chromium stainless steel or chromium carbide, depending on metal composition	0.5–2 mil	1600–2300 Vickers for chromium carbide case	High resistance to wear, abrasion, corrosion
Flame Hardened Surface	Surface structure changed by heating surface only with oxyacetylene flame above transformation range, followed by quenching	Any steel that can be hardened by conventional methods	Hardened surface structure. No change in chemical composition	0.06–0.25 in.	Max hardness depends on carbon content of base metal	High hardness, resistance to wear and abrasion
Induction Hardened Surface	Surface structure changed by heating surface only by means of electrical induction above transformation range, followed by quenching	Medium carbon steels, gray cast iron, pearlitic malleable and nodular cast irons	Same as flame hardened surface	0.015–0.125 in.	Max hardness depends on carbon content of base metal	Same as for flame hardened surface
Chromium Plate	Electrodeposition of chromium	Iron, steel, copper, nickel, zinc, aluminum, magnesium, titanium, brass	Chromium	Approx 1 mil max	Up to 1000–1025 Brinell	High hardness, excellent corrosion resistance, low coefficient of friction, nongalling and nonwetting
Nickel Plate	Electrodeposition of nickel	Iron, steel, copper, zinc, aluminum, magnesium, brass	Nickel	Up to ¼ in.	150–800 Vickers	High wear, corrosion resistance
Rhodium Plate	Electrodeposition of rhodium	Most metals, including gold, silver, electrical contact materials	Rhodium	0.001–1 mil	540 to 640 Vickers (20-gm load)	High hardness and wear resistance, attractive appearance
Hard Anodized Coating	Surface converted to metallic oxide or other inorganic compound by electrochemical process in which base metal is made anode in electrolyte	Most aluminum alloys and magnesium	Case consisting of oxides or other inorganic compounds of the base metal	Approx 1–5 mils	Difficult to assess by conventional methods	Better resistance to abrasion, erosion and corrosion than base metal
Sprayed Coating	Metal or ceramic layer applied by spraying molten or semimolten particles which fuse, cool and solidify on surface. Surface temperature ranges up to 800 F	Most commonly used metals	Bronze, various irons and steels, molybdenum, aluminum or zirconium oxide, zirconium silicate, tungsten carbide	Metals: up to ⅛ in. Ceramics: 0.005–0.050 in.	Up to 1350 Vickers for tungsten carbide	Extremely wide range of surface properties, depending on coating material

Chemical Conversion Coatings

Purpose and Type ↓	How the Coatings Compare	Metals That Can Be Coated[a]									
		Aluminum	Cadmium	Copper	Iron	Magnesium	Silver	Steel	Tin	Titanium	Zinc
To Improve Paint Bonding											
Phosphate	Rough crystalline structure provides excellent paint adhesion. Better paint bond than chromate coatings. Corrosion confined to limited area when paint film damaged	X	X		X	O		X	O		X
Chromate	Provides high corrosion protection because of nonporous structure. Paint adhesion generally not as good as with phosphate	X	X	O	O	X	O	O	O		X
To Improve Corrosion Resistance											
Anodic	Provides equal or better corrosion protection—at higher cost—than chromate	X				X					O
Chromate	Generally provides much better corrosion resistance than phosphate. Nonporous structure acts as moisture barrier. If coating is broken, inhibiting action of soluble chromate retards corrosion of basis metal	X	X	X	O	X	O	O	O		X
Phosphate	Not generally used alone for corrosion protection. When treated with oils, waxes or stains, however, it provides good protection, especially on ferrous surfaces	X	O		X			X	O		X
Oxide and Other	Do not provide as much protection as other conversion coatings, but cost is lower	O	O	O	O			O			O
For Decoration											
Chromate	Available in wide variety of natural and dyed colors. Colors are not as light-fast as in colored anodic coatings	X	X	X	O	X		O	O		X
Anodic	Can be colored with a large variety of dyes and pigments. Underlying metal can be used to impart attractive metallic sheen. Sealing required	X				X					O
Phosphate	Little decorative value except when painted	X	X		X	O		X	O		X
Oxide and Other	Black and blue-black coatings widely used to decorate ferrous, zinc and cadmium surfaces. Considerable number of colors producible on copper and aluminum	X	X	X	X			X			X
To Aid In Cold Forming											
Phosphate	By preventing metal-to-metal contact, lubricated coating facilitates deep drawing, cold heading, extrusion, and wire and tube drawing	X			X			X			X[b]
Oxide and Other	Special coatings have been developed for titanium									X	
To Improve Wear Resistance											
Phosphate	Maintains continuous oil film between bearing surfaces; prevents welding of surfaces under load				X			X			
Anodic	Hard anodic coating with greater thickness and weight than conventional anodic coatings increases wear and abrasion resistance	X				X					

[a] X—Metals most commonly treated for purpose listed. O—Metals less commonly treated. [b] Electroplates.

Clad and Precoated Metals

Surface ↓	Base Metal		Critical Functions, Properties	Typical Applications
	Metal	Form		
Aluminum and Its Alloys				
Aluminum (hot dipped)	Steel, low carbon or copper-bearing	Sheet, strip	High heat reflectivity. High temperature oxidation resistance. Forms refractory alloy at 1000 F. Strong, low cost base	Oven door liners, aircraft fire walls, auto mufflers, broiler and toaster parts, baffles for space heaters, jet engine parts
	Steel (ASTM A122)	Strand (7-wire)	Galvanic protection. Strong base. Longer life than zinc-coated steel	Guy wires, span wires, overhead ground wires
Aluminum[a] (clad)	Steel, low carbon	Strip	High temperature oxidation resistance. At 1000 F forms alloy with 85% emissivity. Cheaper than carbonized nickel or nickel-clad steel. Conserves nickel	Anode plates for electronic receiving tubes
Aluminum[b] (clad)	Steel, low carbon	Strip	Same as above, but suitable for higher temperatures	Anode plates for receiving tubes where close spacing makes temperatures too high for aluminum
1100 (clad)	Aluminum (2024)	Sheet	Atmosphere resistance. Galvanic protection. Strong base	Aircraft frames, cooking utensils, hardware
6053 (clad)	Aluminum (2014)	Sheet	Atmosphere and wear resistance. Galvanic protection. Workable base	Power shovel bails, aircraft fittings, heavy duty forgings
6053 (clad)	Aluminum (5056)	Wire	Same as above	Insect screening
7072 (clad)	Aluminum (3003 or 3004)	Sheet	Atmosphere resistance. Galvanic protection. Workable, weldable base	Cooking utensils, gasoline and oil tanks, bus and train trim
7072 (clad)	Aluminum (3003)	Tube	Same as above	Heat exchangers
7072 (clad)	Aluminum (7075)	Sheet	Atmosphere resistance. Galvanic protection. Strong base	Aircraft structural parts
Copper and Its Alloys				
Brass, Copper (electroplated)	Steel, low carbon	Sheet, strip	Decoration. Atmosphere resistance. Good solderability	Luggage, hardware, costume jewelry, tubing, frames, stands
Brass[c] (clad)	Steel, low carbon	Strip	Same as above	Cosmetic cases, frames, gaskets
Brass[d] (clad)	Steel, low carbon	Wire	Decoration. Atmosphere resistance. Strong base. Conserves brass	Curtain rods, indoor television antennas, lamp stands
Brass, Copper (electroplated)	Zinc	Sheet, strip	Decoration	Moldings, ornaments, trim, badges, buttons
Bronze[e]	Steel, low carbon	Strip	Decoration. Atmosphere resistance. Strong base. Conserves copper	Ornamental trim, shell cases
Copper (clad)	Steel, carbon	Wire, ribbon	Electrical conductivity. Atmosphere resistance. Strong base. Conserves copper	Lead-in wires for electronic tubes, communication and power lines, springs
	Aluminum (1100 or 5052)	Sheet, strip, tubing, wire, bars	Thermal, electrical conductivity. Good solderability. Lightweight base. Conserves copper	Waveguides, variable condenser blades, heat transfer fins, jewelry, shims, bushings
	Beryllium copper (25)	Strip	Electrical conductivity. Good spring properties	Current-carrying springs
	Steel, low carbon	Strip	Atmosphere resistance. Thermal conductivity. Good solderability. Strong base. Conserves copper	Gaskets, automotive radiator tanks, electrical contacts and switches, immersion heater base plates
	Steel, high carbon	Strip	Electrical conductivity. Plating base. Good spring properties	Clips, thin-blade or spiral-type springs
	Steel, low alloy (with boron)	Wire	Electrical conductivity. Atmosphere resistance. Strong base. Conserves copper	Grid support rods for electronic tubes, communication lines, plated costume jewelry
	Steel, carbon or low alloy	Plate, heads	Resistance to corrosion, erosion. Conserves copper	Chemical process equipment
Cupro-Nickel (clad)	Steel, low carbon	Strip	Same as above	Chemical process equipment
Phosphor Bronze[e] (clad)	Copper	Strip	Good spring properties. Base has high electrical conductivity	Current-carrying springs and blades

[a] 1½% silicon. [b] 1½% silicon with 330 nickel on other side. [c] 70–30 or 85–15. [d] Over copper. [e] 90–10.

continued on next page

Clad and Precoated Metals

Surface ↓	Base Metal		Critical Functions, Properties	Typical Applications
	Metal	Form		
Chromium, Gold and Its Alloys				
Chromium[f] (electroplated)	Aluminum, brass, copper, zinc	Sheet, strip	Decoration	Toys, reflectors, trim, signs, auto accessories
	Steel, low carbon	Sheet, strip	Decoration, atmosphere resistance	Heater and toaster shells, tubes
Gold[g] (clad)	Bronze, nickel silver, nickel, sterling silver	Strip, tubing, wire	Decoration. Atmosphere resistance. Relatively low cost base	Jewelry, including watchcases, bracelets, rings, lockets
Gold[h] (clad)	Copper, brass, nickel, monel	Strip	Chemical resistance. Relatively low cost base	Bursting disks, other chemical process equipment
Lead and Its Alloys				
Lead[i] (electroplated)	Steel, low carbon	Sheet, strip	Atmosphere resistance. Good solderability, drawability	Telephone cable sheathing, containers
Lead (electroplated or hot dipped)	Copper (ASTM B101)	Sheet, strip	Atmosphere resistance	Roofing, flashing
Lead[j] (clad)	Copper, low carbon steel	Tubing	Chemical resistance. Good strength, high thermal conductivity	Heat exchanger coils for chemical process equipment
Lead (clad)	Steel, low carbon	Plate, sheet, strip, rod	Chemical resistance. High density. Strong base	X-ray, radium, nuclear and chemical equipment
Lead[k] (hot dipped)	Steel, low carbon	Sheet, strip	Atmosphere resistance. Good solderability, drawability. Paint base	Ammunition boxes, ducts
Terne[l] (hot dipped)	Steel, low carbon	Sheet	Atmosphere resistance. Good solderability, drawability. Paint base	Gasoline tanks, caskets, paint and oil containers, door frames
Nickel and Its Alloys				
Inconel, Monel (clad)	Steel, carbon or low alloy	Plate, heads	Resistance to corrosion, erosion. Low cost base. Conserves nickel	Process equipment
Monel (clad)	Steel, low carbon	Strip	Same as above	Process and marine equipment
Nickel (electroplated)	Aluminum, brass, copper, zinc	Sheet, strip	Decoration	Lighting fixtures, nameplates, lids, grids, caps, disks, frames
Nickel (clad)	Copper	Wire, ribbon	High temperature oxidation resistance. Electrical conductivity	Electrical circuits subjected to high temperatures
Nickel[d] (electroplated)	Steel, low carbon	Sheet, strip	Decoration, atmosphere resistance	Toys, nameplates, trays, knives
Nickel (clad)	Iron or carbon steel	Wire, ribbon	Atmosphere resistance. High temperature oxidation resistance	Grid support rods, lead-in wire for tubes; typewriter key levers, springs
A Nickel (clad)	Copper	Wire, ribbon	Corrosion resistance. Electrical conductivity	Electrical circuits subjected to corrosive atmospheres
A or L Nickel (clad)	Steel, carbon or low alloy	Plate, heads	Resistance to corrosion, erosion. Low cost base. Conserves nickel	Process equipment
L Nickel (clad)	Brass, low carbon steel	Strip	Same as above	Process equipment
330 Nickel (clad)	Steel, low carbon	Strip	High temperature oxidation resistance. High emissivity. Conserves nickel	Anode plates for electronic receiving tubes
Platinum and Platinum Group Alloys, Silver				
All (clad)	Copper, brass, bronze, nickel	Strip	Electrical contact properties. Chemical resistance. Low cost base	Electrical contacts, slip rings, chemical crucibles
Platinum (clad)	Copper, brass, bronze, nickel	Tubing, wire	High chemical resistance. Low cost base. Thermal conductivity	Heat exchangers for chemical processes
Platinum (clad)	Molybdenum	Wire	High work function (low primary electron emission). Refractory base	Grids for tubes, particularly for use with thoriated cathodes

[f] Over nickel. [g] 10K or more. [h] 14K or more. [i] Sometimes over copper. [j] ASTM B29. [k] 90–95%. [l] 75–85% lead.

Clad and Precoated Metals

Surface ↓	Base Metal		Critical Functions, Properties	Typical Applications
	Metal	Form		
Platinum and Platinum Group Alloys, Silver (continued)				
Silver (clad)	Copper, nickel	Wire, ribbon	Atmosphere resistance. High temperature oxidation resistance. Electrical conductivity. Low cost base	High temperature coils, high frequency conductors, braiding for radar cables
	Aluminum (1100, 5052)	Strip	Electrical contact properties. Electrical conductivity. Lightweight, low cost base. Decoration	Conductors, contacts in aircraft electrical equipment; costume jewelry
	Aluminum, brass	Tubing	Electronic transmission characteristics. Low cost base	Waveguides for electronic transmission lines
	Beryllium copper (25)	Strip	Electrical conductivity and contact properties. Good spring and fatigue properties	Contact arms for buzzer circuits, other current-carrying springs
	Copper, brass	Strip	Electrical contact properties. Low cost base	Electrical contacts, slip rings, flexible waveguides
	Invar	Strip	Good electrical contact properties. Low thermal expansion	Television antenna connectors
	Monel, nickel	Strip	Electrical contact properties. Corrosion resistance. Low cost base	Electrical contacts subject to corrosion or excessive wear
	Phosphor bronze (A, C, D)	Strip	Electrical conductivity and contact properties. Good spring properties	Electrical contact springs
Stainless Steel				
Austenitic[m] (clad)	Copper	Strip	Resistance to corrosion, erosion. Thermal conductivity. Workable base	Heat exchangers for chemical processes
Ferritic[n] (clad)	Copper	Strip	Corrosion resistance. Thermal conductivity. Uniform heat transfer. Workable base. Decoration	Pots and pans
Stainless (clad)	Steel, carbon or low alloy	Plate, heads	Resistance to corrosion, erosion. Workable low cost base metal	Process equipment
Stainless (clad)	Steel, low carbon	Sheet, plate	Same as above. Decoration	Process equipment, auto bumpers, grilles and trim, display cases, sterilizers
Ferritic[n] (clad)	Steel, low carbon	Strip	Corrosion resistance. Decoration. Workable, low cost base metal	Cooking utensils, auto bumpers, grilles and trim
Tin, Zinc				
Tin (electroplated)	Steel, low carbon	Sheet, strip	Resistance to atmosphere, chemicals. Good solderability. Strong, low cost base	Food product cans, kitchenware, bearings (babbitting base), parts to be soldered
Tin (hot dipped)	Steel, low carbon	Sheet, strip	Same as above	Tin cans for food products
Zinc (electroplated)	Steel, low carbon	Sheet, strip, flat wire	Atmosphere resistance. Galvanic protection. Strong, low cost base	Lighting fixtures, refrigerator parts, spools and reels, oil cans, signs
Zinc (hot dipped)	Steel, low carbon (incl ASTM A123)	Plate, bar, sheet, strip, shapes	Same as above	Agricultural, refrigerator and air conditioner parts, auto mufflers
	Steel, carbon or low alloy (ASTM A53)	Tubing, pipe, conduit	Same as above	Water pipe. Electrical and hot air conduits
	Steel, low carbon	Wire	Same as above	Fencing
Organic Coatings				
Alkyd Baking Enamel	Low carbon steel, aluminum	Strip	Decoration, atmosphere resistance	Venetian blinds, auto dashboards, lighting fixtures, awnings
All	Steel, aluminum, brass, zinc	Strip	Same as above	Toys, reflectors, brackets, frames, caps, movie reels, ashtrays, auto moldings and trim, novelties
Polyvinyl Chloride	Steel, aluminum, magnesium	Sheet, strip	Decoration. Resistance to atmosphere, chemicals. Abrasion resistance. Formability. Low cost base	Business machine housings, auto panels, television cabinets, air conditioner housings
Vinyl Lacquer or Enamel	Low carbon steel, aluminum, brass, zinc	Strip	Decoration. Atmosphere resistance. Formability	Caps, lipstick cases, garden tools, toys, eyelets, flashlight parts

[m] 304, 310.

[n] 430.

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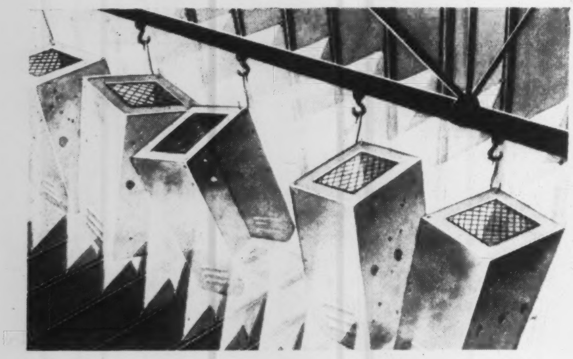

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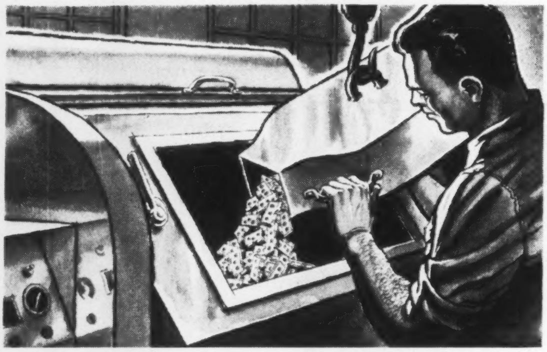

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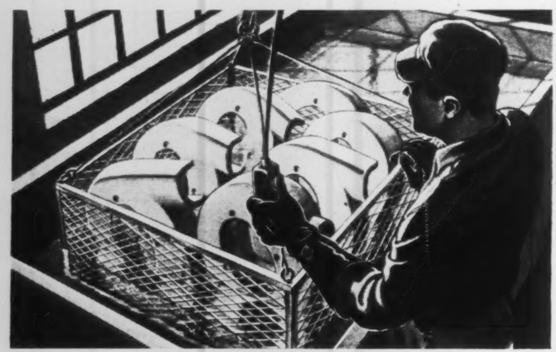

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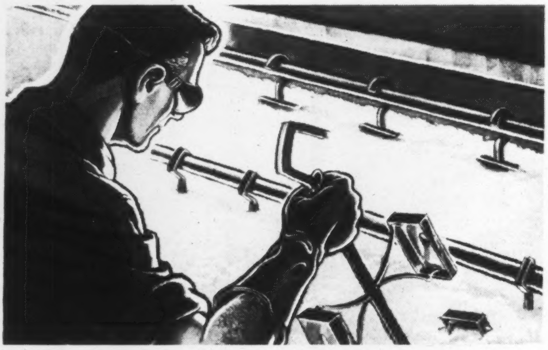

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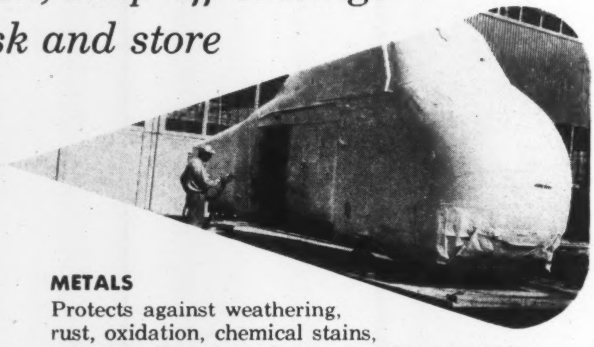

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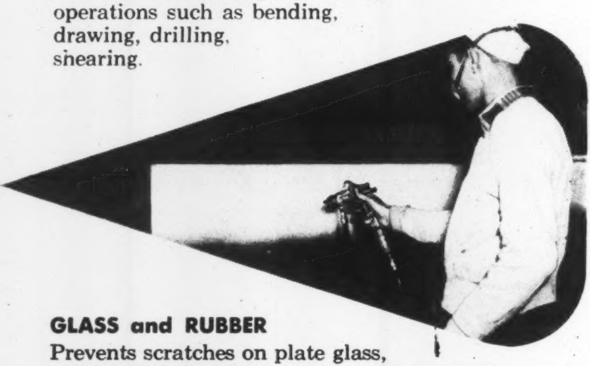

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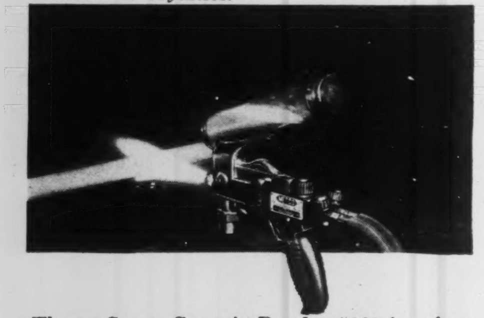

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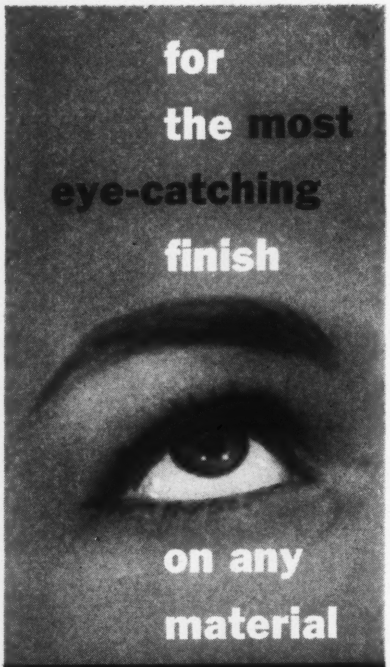
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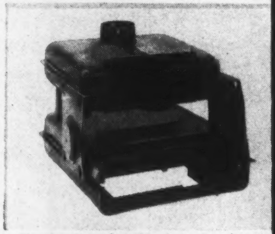

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Industrial atmospheres, salt air, wind-driven gases and smoke are combatted successfully by Porcelain Enamel. Neither color nor finish is adversely affected by heat, cold, rain, snow, ice and sunlight.

Representative Applications

Outdoor Signs • Panels, Mullions, Coping, Fascia and Similar Architectural Members • Industrial Buildings • Gasoline Pump Housings • Lighting Fixtures • Downspouts • Roofs • Billboard Components • Marquees

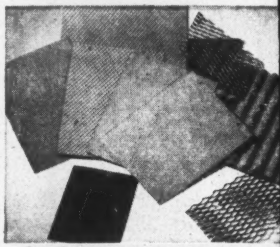
Outdoor architectural applications.

COLORS AND TEXTURES

Most all colors of the visible spectrum in solid or variegated appearances. Corrugated, embossed and other textured metals may be used. Pebbled, stippled and speckled textures ranging from high gloss to full matte.

Representative Applications

Range, Refrigerator, Washer and Dryer Components • Architectural Panels • Cooking Ware • Ship Bulkheads • Vending Machines • Toasters • Art Ware • Lamp Bases • Space Heater Cabinets



Broad variety of textures and colors.

ENAMEL

A HIGHLY
VERSATILE PRODUCT
COMBINING
HARDNESS OF GLASS AND
STRENGTH OF STEEL

New Technical Developments Make It An Even More Functional Design Material

Technical developments such as those outlined here have broadened substantially the range of applications where Porcelain Enamel can serve. Today Porcelain Enamel is no single material, but a whole class or family of materials embracing thousands of separate formulations.

Improvements in Frit Formulations

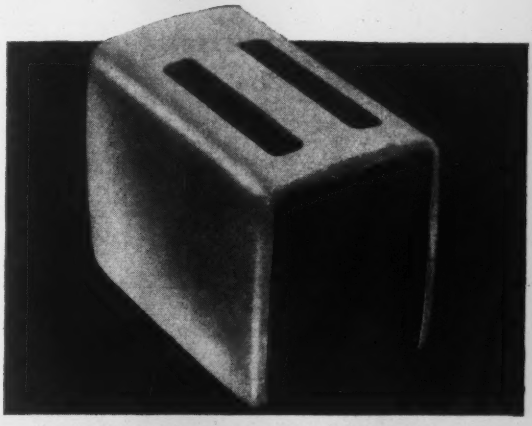
Some of the most dramatic technical advances have resulted from improvements in formulations for frit, the basic raw material in Porcelain Enamel. Frit now is a custom-designed material which is compounded specifically to produce optimum characteristics for every Porcelain Enamel application.

Thinner Coatings

Reduction in over-all thickness produces a significant lessening of the danger of mechanical damage and also improves resistance to thermal shock. The result is an economical product of greater strength and durability—with no sacrifice of hardness, corrosion resistance, gloss, color or other characteristics.

Lower Firing Temperatures

Special frits, together with refinements in enameling techniques, have allowed enameling temperatures to be reduced by as much as 200°F. Now more complex steel shapes can be fired without distortion. Also, with many products extra bracing and other special designs formerly required are no longer necessary.



More complex steel shapes, such as this toaster housing, now can be Porcelain Enameled due to lower firing temperatures.

Improved frit formulations have done much to broaden applications for Porcelain Enamel.

NOW AVAILABLE! NEW PORCELAIN ENAMEL ENGINEERING DATA FILE

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☐ Please send information about possible application of Porcelain Enamel

to__________________________________
(type of product)

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BRANSON

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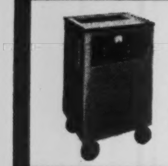

½-gallon and larger benchtop models, and (illustrated) 5- and 12-gallon self-contained rollaround units.

Built-in cabinet-type wash-and-rinse cleaning systems.

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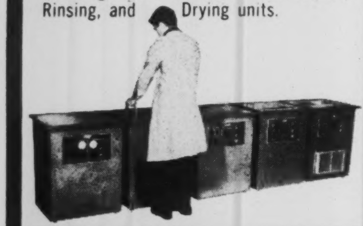

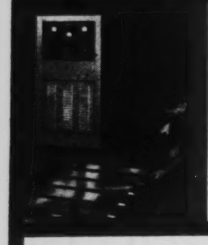

Custom-engineered cleaning installations: for batch and conveyorized cleaning, and for continuous-flow cleaning in strip and wire mills.

Branson offers experienced counsel in adapting the flexibility of SONOGEN® Ultrasonic Cleaning Equipment to **your** needs. Tell us the problem, and we'll follow through from planning and installation to maintenance, with factory-trained specialists available nationwide.

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ORDINARY METALS TO

4500° F!

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VINYL-METAL LAMINATES IN DESIGN

CLAD REX

The broad effect of CLAD-REX® on industrial design, engineering, and selection of materials

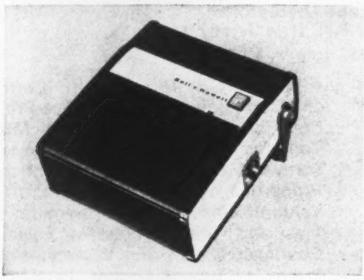
Reaction to the potential offered by vinyl-clad metals is contradictory. The potential advantage is so broad that it's hard to believe. But, when full realization does begin to develop, enthusiasm tends to go too far!

Therefore, your vinyl-clad metals data file should be assembled with care. Know exactly what you are considering, when to use it, and how.

Clad-Rex is a vinyl-metal laminate. Specifically, a calendered, semi-rigid poly-vinyl chloride film bonded to sheet metal. All alloys and tempers of aluminum and steel (including galvanized and aluminized) are commonly used. However, other metals can be used where their special properties are important to end product performance.

The sales appeal of Clad-Rex vinyl-metal laminate

The words *calendered* and *film* mean styling in Clad-Rex is unlimited, because film can be printed. Simulated wood-grains and leathers, as well as any color, combination of colors, texture or pattern can be used. Or you can design your own, if you prefer.



This unlimited choice ranges from sparkling burnishes including high metallics, to non-reflective matte finishes (or variations between) as well.

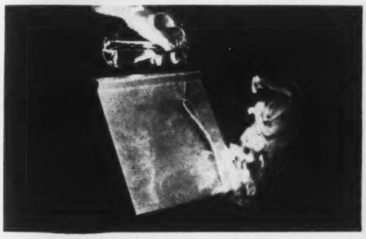
The abrasion resistance of Clad-Rex vinyl-metal laminates

The words *semi-rigid* and *poly-vinyl chloride film* mean Clad-Rex has unusual resistance to abrasion. Therefore, products made of Clad-Rex are more durable and suited to usage where abrasion resistance is required.

However—most important to manufacturing—Clad-Rex can be processed without the careful handling or rejects common to other pre-finished metals. This advantage in itself results in a substantial saving in cost. Even the finishing of *un*finished metals leads to a reject factor that becomes a savings when Clad-Rex is used.

The corrosion resistance of Clad-Rex vinyl-metal laminates

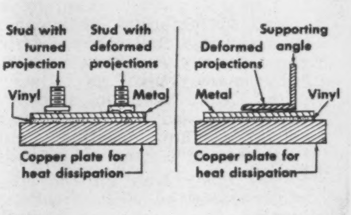
The words *poly-vinyl* and *chloride* become important again, because of the inherent properties of the Clad-Rex vinyl. It provides excellent resistance to acids and alkalis, as well as other corrosive chemicals. It also has high dielectric properties.



The fabrication of Clad-Rex vinyl-metal laminates

Clad-Rex can be formed in almost as many ways as any *un*finished sheet metal—including deep drawing!

Resistance welding, generally, is limited to projection techniques.


Stud with turned projection
Stud with deformed projections
Vinyl
Metal
Copper plate for heat dissipation
Supporting angle
Deformed projections
Metal
Vinyl
Copper plate for heat dissipation

However, the resistance welding equipment must be (1) tooled for series welding procedures (both electrodes on same side of sheet), and (2) capable of very short weld times with extremely fast follow-up of forging pressure.

Epoxy resins are proving quite successful for assembly. Clamps can be eliminated by using resistance weld tacking or interlocking design.

The cost advantage of Clad-Rex vinyl-metal laminates

As a purchased material going into a user's plant, vinyl-metal laminates cost more than *un*finished or some other pre-finished metals. *But, most important, end products made of Clad-Rex generally cost less!*

The reasons are worthy of close examination:

(1) Parts made of Clad-Rex require no further finishing. This is a savings in equipment, finishing material, factory floor space, labor, handling, etc.

(2) The abrasion resistance of Clad-Rex substantially reduces (and often eliminates) rejects. This includes both rejected products *and* the expensive handling, reworking activities, and labor required.

The broad effect of Clad-Rex vinyl-metal laminates on manufacturing literally simplifies your processing operations. Movement of sub-assemblies, etc., through your plant actually becomes more direct—out of your dies into assembly!

A source of engineering and manufacturing service for you

Clad-Rex interest in helping you extends into your own plant. Free of charge, a Clad-Rex Fabricating Engineer is provided to show your production people how easy it is to process Clad-Rex.

Furthermore, Clad-Rex operates a fully staffed and equipped research laboratory. Its facilities are devoted to customer service as well as improving Clad-Rex itself.

Write and describe your product. See how Clad-Rex can work its broad effect on industrial design, engineering and selection of pre-finished metals in your product. **Clad-Rex Division of Simoniz Company, 2111 Indiana Avenue, Chicago 16, Illinois. Telephone: VIctory 2-7272.**

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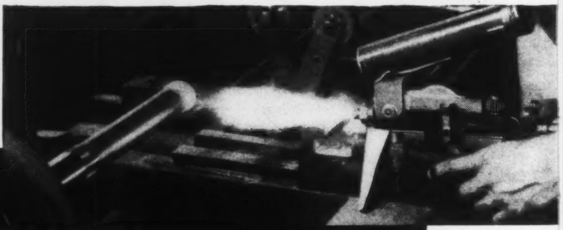

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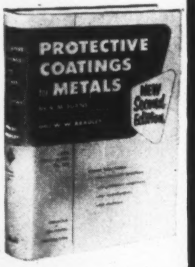
by **R. M. BURNS**, formerly Director of Chemical and Metallurgical Research, and **W. W. BRADLEY**, Technical Staff, both of Bell Telephone Laboratories, Murray Hill, New Jersey

ACS Monograph No. 129 • 1955, 657 pages, $12.50



Now completely revised, enlarged, and brought up to date, this important new edition contains latest information on the composition, properties and performance of both metallic and organic coatings.

Completely new chapters are devoted to inhibitors, chemical conversion coatings and sprayed metal coatings. Newly experienced troublesome phenomena known as "silver migration" and "metallic whiskers" are fully discussed, and latest practices in metal cleaning, coating application and coating testing are explained.

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AMCHEM Information Bulletin

CHEMICAL PREPAINT TREATMENTS FOR METAL SURFACES

What they do, the types available, how they are applied

By J. H. GEYER, Manager, Product Development Dept., AMCHEM PRODUCTS, INC.

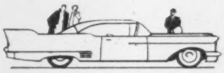
Paint systems have been steadily improved in an effort to produce more decorative, easier-to-apply, and more corrosion-resistant films. The ability, however, of any paint film to perform its predetermined functions cannot be fully utilized without properly preparing the metal surface.

Chemical *prepaint* treatments are designed to do four jobs and do them well. First, they remove organic soils, shop dirt, scale, and rust or corrosion products from the metal surface. Second, they provide surfaces that are completely compatible with subsequent paint films. Third, they produce a *tooth* that promotes good paint film adhesion. Fourth, they effectively prevent underpaint corrosion growth after any breakthrough in the paint film.

Basically, there are four types of chemical prepaint treatments—phosphoric acid, iron phosphate, zinc phosphate, and amorphous phosphate or chromate.

Phosphoric Acid—Phosphoric acid cleaner combination materials are an example of economical chemical prepaint treatments. Amchem Deoxidine is such a material. It removes organic soils, rust, scale and contaminating elements from the metal surface. It also produces a light etch on steel, aluminum or zinc surfaces which considerably aids in increasing paint adhesion. It does not, however, form an actual coating on the metal surface. Any breakthrough in the subsequent paint film will permit underfilm corrosion to proceed. Grades of Deoxidine are available for application by brush or swab, hot and cold dip, or hot spray.

Iron Phosphate—Iron phosphating processes are extensively used in the chemical prepaint treatment of appliances—water heater shells, ranges, washers, dryers and other *white lines*. These processes will produce excellent paint-bonding films on the metal and retard or prevent underpaint corrosion. Duridine, Amchem's iron phosphating process, is a combination organic soil cleaner and iron phosphate coating material. Both the cleaning and coating operations take place in the same bath. Duridine and other iron phosphates do not lend themselves to brush-on application, are primarily designed for spray type equipment of four or five stages. But several dip installations are successfully operating today by inclusion of an alkali precleaning stage.



Zinc Phosphate—Amchem Granodine is an example of zinc phosphating, the type now being used to treat steel in the automotive industry, and predominantly specified for steel ordnance and military items. This process forms a coating which offers the ultimate in paint adhesion promotion and vastly augments the corrosion resistance of subsequent paint films. Zinc phosphate materials are extremely flexible as to method of application—can be applied by brush, dip or automatic spray equipment. In a typical dip or power spray system, the stages would be alkali clean, water rinse, zinc phosphate treatment, water rinse, acidulated final rinse. If the metal has considerable areas of rust or scale, an acid pickle is advisable following the alkali cleaning stage.

On zinc surfaces, the zinc phosphates perform a rather unique function. They act as a barrier against chemical reaction between the applied paint film and the zinc surface. This effectively prevents blistering of the paint and early breakdown of the film. This is in addition, of course, to the improvement of paint adhesion and the retarding of underpaint corrosion. Amchem Lithoform is specially designed for use over zinc surfaces and finds wide application as a prepaint treatment for ornamental zinc die castings, refrigerator liners, and on most galvanized work requiring painted finishes.

Amorphous Phosphate and Chromate—These coatings are the films produced by the Amchem Alodine processes and similar ones on aluminum surfaces. They have met with wide acceptance in the prepaint treatment of venetian blind strips, refrigerator liners, aluminum heat transfer units, aircraft sheet metal assemblies, and many other items fabricated from aluminum. The various coatings provide an excellent film for the promotion of paint adhesion and effectively prevent underfilm corrosion. As in the case of zinc, aluminum exhibits a tendency to chemically react with some paint systems. The Alodine processes develop a barrier film between the paint and the aluminum surfaces which prevents this reaction. The Alodines are extremely versatile materials that can be applied to aluminum surfaces by brush, hand spray, dipping, or mechanical spraying. Brush application is particularly well adapted to the processing of parts too large for simple dip systems or in manufacturing operations that do not warrant a tank setup. In dip or spray application, the system usually consists of an alkaline preclean, a water rinse, the Alodine treatment, a water rinse, and an acidulated final rinse. Where the surface is heavily oxidized, a deoxidizer in the line is needed.

For more complete information about any one or all of these chemical conversion coatings, contact an Amchem sales representative or write us at Ambler 17, Pa.

AMCHEM **AMCHEM PRODUCTS, INC.** (Formerly American Chemical Paint Co.)

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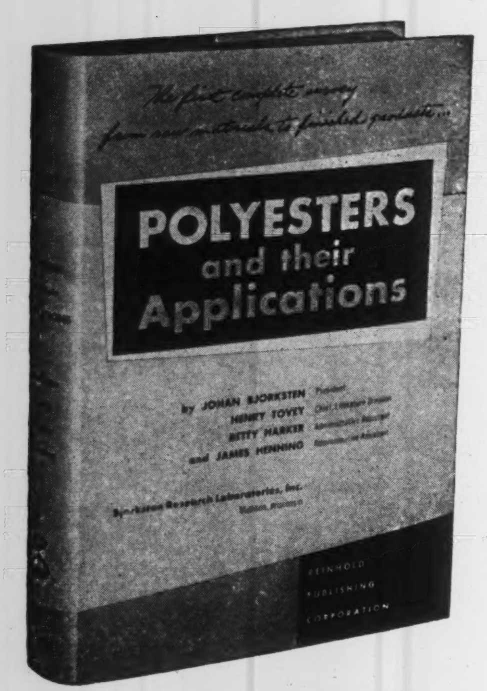
A treasury of valuable information for the plastics industry . . .

POLYESTERS



1956, 626 pages, $10.00

and their Applications

by JOHAN BJORKSTEN
President

HENRY TOVEY
Chief, Literature Division

BETTY HARKER
Administrative Assistant

and JAMES HENNING
Administrative Assistant

all of Bjorksten Research Laboratories, Inc.
Madison, Wisconsin

This book is the first comprehensive survey of the entire polyester field from raw materials to fabricated product. The text and annotated bibliography of over 3300 references cover most phases of the production and use of polyesters. You will find here a storehouse of valuable information and a tremendous time-saver in seeking background information. Now you can quickly locate any patents or literature bearing on some particular phase of the polyester field. Included are not only the unsaturated polyesters used in molding, casting, coating, impregnating, and laminating, but also the saturated polyesters used in production of fibers, films, elastomers, and foamed plastics.

This fund of information has been painstakingly assembled for many years by the Bjorksten Research Laboratories. Periodic volumes will be published when merited, to make them a basic reference work covering the current status of the field and indicating the problems which must be overcome for further advancement and the directions of future trends.

The remarkable value of this book will be quickly apparent when you glance through it and realize the cost involved in the endless task of amassing the data and keeping it up to date.

Notice the wide range
of information
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1 THEORETICAL CONSIDERATIONS
   Introduction; General Concepts; Polyesters

2 UNSATURATED POLYESTERS
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3 SATURATED POLYESTERS
   Linear Fiber-Forming Polyesters; Di-Isocyanate-Modified Polyesters

4 TESTING
   Introduction; Raw Materials; Resins and Plastics; Equipment for Testing Plastics; Catalysts; Glass Fillers; Design Data and Nondestructive Tests

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ANOTHER REPORT FROM THE ALMCO ALBUM OF NEW PRODUCTS

To know what's new in Barrel Finishing

Keep Your Eye on ALMCO!

The right machine, the right method, the right media . . . that's the basis for planning any ALMCO *Supersheen* System. And a continuing program of research, ever seeking even better barrel finishing . . . that's the secret of ALMCO progress in making metal finishing easier, faster and finer . . . and more profitably productive for you. Shown below are typical recent developments that give concrete meaning to the phrase, "*To know what's new in barrel finishing, keep your eye on ALMCO!*"

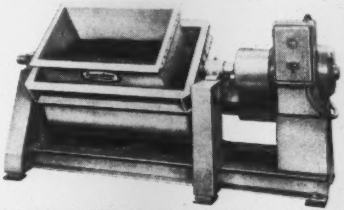
New Spindle Machine

For precision finishing of complex high-quality components such as gears, bearing cages, spline shafts, pump rotors, jet blades, etc., on a continuous production line basis. Large parts or clusters of smaller parts are chucked directly to spindles from single operator's work station. Spindles lower parts into high velocity stream of abrasive media contained in tub that rotates at controlled speed. Spindles themselves also rotate while in the abrasive stream, uniformly exposing parts to the abrasive stream. Indexing head slowly carries all spindles in 1 to 9 min. trip around the tub. All surfaces get the same amount of precision finishing.

Models available with automatic or manual indexing, 2 to 16 spindles, tub diameters of 48" to 90", and drives of 5 to 30 hp.

New ALMCO VIBRASHEEN

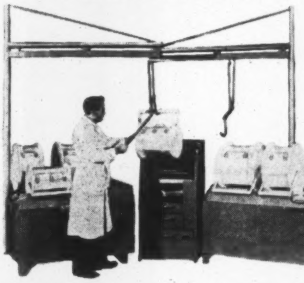
The new *Vibrasheen* method is particularly suited for faster burr removal from parts and finishing hard-to-reach internal crevices. This amazing metal finishing machine vibrates a full 5 cu. ft. load of parts and media . . . uses scrubbing action to remove burrs and finish parts in a fraction of the time needed in ordinary operations. Smaller and larger models also available.



Container pivots 120° to facilitate loading and unloading.

ALMCO *has the right New* BARREL FINISHING EQUIPMENT *for you!*

New ALMCO Roll Barrels



One man operates entire Roll Barrel System. Makes low-cost precision barrel finishing available to any deburring and finishing department! Ideal for finishing large variety of small lots of parts.

New Barrel Finishing Compounds

No. 407. An alkaline powdered composition used in cleaning, brightening and grinding ferrous parts.

No. 408. A very fine silica flour base powdered abrasive grinding compound for use with all metals and alloys. Provides ultra-low micro-inch finishes.

No. 410. An alkaline compound for one operation light deburring and color cycles on ferrous metals.

No. 412. A highly concentrated burnishing compound with tallow and oil soap base for use on both ferrous and non-ferrous metals.

No. 501R. A concentrated mild alkaline compound to inhibit rusting of all ferrous metals. Retains high burnishing finish.

43 other *Supersheen* compounds, plus a complete line of media, are also available from ALMCO. Ask how you can enjoy quantity discounts with the ALMCO Blanket Order Program! Start saving today!

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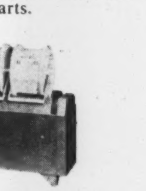

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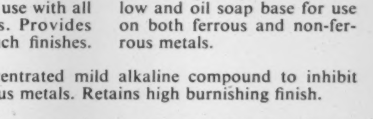

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Forms and Shapes of Materials

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Design Features of Metal Forms

Form ↓	Choice of Materials	Complexity of Part	Maximum Size	Minimum Size
Sand Castings	Wide—ferrous and nonferrous metals	Considerable—holes, bosses, locating pads	Great—largest forms made are sand castings	⅛ in. is smallest practicable section
Shell Mold Castings	Wide—same as above excepting low carbon steels	Moderate—limited by mold removal problem	<60 in. square. Best for smaller parts	1/16-in. sections
Permanent Mold Castings	Restricted—brass, bronze, aluminum	Limited—restricted by use of rigid molds	Moderate—50 lb is practical limit in aluminum	1-oz. sections as thin as 0.1 in.
Plaster Mold Castings	Narrow—brass, bronze, aluminum	Considerable—mold destroyed in removal	Moderate—up to 15 lb in most materials	Small—1/32-in. sections possible
Investment Castings	Wide—includes materials hard to forge or machine	Considerable—very few limitations	Moderate—best for parts under 2 lb	Small—sections down to 0.030 in.
Die Castings	Narrow—zinc, aluminum, brass, magnesium	Considerable—though costly dies might be required	Large—up to 75 lb in aluminum, 200 lb in zinc	Sections as small as 0.025 in.
Drop Forgings	Medium—many ferrous, nonferrous alloys	Moderate—limited by die restrictions	Large	Small as fraction of an ounce
Press Forgings	Medium—best for nonferrous alloys	Limited—but greater than drop forgings	Large—300-400 lb a practical maximum	Smaller than drop forgings
Upset Forgings	Medium—many ferrous, nonferrous alloys	Limited to cylindrical shapes	Medium—9-in. bar about largest	Moderate—not comparable to casting
Cold Headed Parts	Narrow—confined to steel, highly ductile alloys	Limited—less flexibility than forgings	Small—7 in. by ½ in. dia usual maximum	Small—⅛-in. dia parts can be made
Continuous Cast Parts	Narrow—bronze, nickel bronze	Limited—can be complex in cross section only	Moderate—9 in. max dia	Moderate—5/32 in. for sections
Extrusions	Restricted—light metals, some steels, copper, titanium	Limited—can be complex in cross section only	Medium—8 to 10 in. max dia	Small—0.050-in. sections in aluminum and magnesium
Impact Extrusions	Narrow—aluminum, magnesium, some steel	Limited—must be concentric	Small—6 in. dia in soft alloy, 4 in. in hard	Moderate—¾ in. dia smallest
Roll Formed Shapes	Narrow—cold rolled steel, some aluminum	Restricted to thin and uniform cross sections	Large	Sections from 0.125 in. up
Stamped and Press Formed Parts	Wide—all workable metals	Moderate—some design restrictions	Large	Small—sections as thin as 0.003 in. possible
Metal Powder Parts	Moderate—iron, steels, nickel, brass, nickel alloys, refractory metals	Limited—powders flow poorly, do not transmit pressure	Small—parts less than 4 in. square best	Small—<1/16 in. dia possible
Spinnings	Wide—many sheet metals	Limited—cylindrical or concentric shapes	Large—up to several feet in dia	Moderate—¼ in. dia in gages less than 0.040 in.
Screw Machine Parts	Wide—best suited to highly machinable metals	Moderate—limited to rotational shapes	Medium—up to 6 in. long, 2½ in. dia	Small—<1/16 in. dia
Electroformed Parts	Narrow—iron, copper, nickel, silver	Great—extreme complexity possible	Limited—½-in. sections can be built up	Small—0.005 in. or less
Tubing	Wide—any ductile metal available in tubular form	Limited by sectional shapes of tubing	Usually 4 to 6 in. o.d.	Moderate—¼ in. o.d.
Welded and Brazed Parts	Wide—dissimilar metals can be joined	Great—extremely complex shapes	Unlimited	Moderate

Mechanical Properties	Precision, Tolerances	Special Structural Characteristics	Surface Smoothness	Surface Detail	Remarks
Fair to high depending upon metal cast	$\pm\frac{1}{16}$–$\frac{1}{32}$ in./in., closer at extra cost	Good bearing structure	Poor	Poor	Usually require some machining before use
Good—little porosity, few gas inclusions	±0.003–0.005 in./in.	High quality for cast metals	Good	Good	Considered best of low cost castings
Good—high in centrifugal castings	±0.01–0.05 in.	As above	Good	Good	Large quantities allow production economies
Fair	±0.010–0.005 in.	—	Good	Good	Little finishing required
Good	±0.005 in./in. common, ±0.002 in./in. possible	High quality for cast metals	Excellent	Excellent	Best for parts too complicated for other casting
Fair	±0.001 in./in.	Special properties can be obtained through use of inserts	Good	Good	Most economical where applicable
High	±0.010–0.030 in. without joining	Grain flow provides toughness	Fair	Fair	Used where high strength is required
High	±0.005 in.	Hot working gives structural advantages	Fair	Fair	Closer tolerances and greater complexity than drop forgings
High	Medium—compare to press forgings	Grain flow provides toughness	Medium	Medium	Best suited to small parts
High	±0.010 in. common, ±0.002 in. possible	Tough structure	High	Fair	High production rates
Good to high depending on alloys	$\pm\frac{1}{64}$ in., closer on rounds	High quality for cast metals	Good	Only as part of contour	Provides long section and complex shapes
Good	±0.005 in. common	Grain flow improves properties	Good	Only as part of contour	Sometimes used as blanks for other processes
High—metal cold worked	±0.001 in. common	Grain flow improves properties	Good	Good	Can eliminate machining
Good	±0.002 in. common	Cold work improves properties	Good	None	Requires large quantities
Good to high	Good—to ±0.001 in. common	—	High	Good to excellent	Extremely low cost in quan, otherwise moderate
Fair to good	Good—±0.001-0.005 in. common	Porosity can be controlled and complex materials formed	Fair	Fair	Can use materials not formable by other processes
Good	Fair—±0.015-0.060 in. common; better at added cost	Grain flow, cold work improve properties	Good	None	Good for large pieces or short runs
High	±0.001-0.005 in. possible	—	Excellent	Good	High production rates, low cost
Fair—lower than wrought	High—±0.002-0.0002 in. common	—	Excellent	Excellent	Best when complexity and accuracy essential
Good—cold working improves properties	Good—depends on quality of tubing	Grain flow improves properties	Good	None	Good means of reducing costs
Variable—depends upon components	Medium—not highly precise	Can combine parts with special properties	Depends on components	None	Often needed to meet design requirements

Castings

General

Sand castings. These castings are usually the first type considered. A major advantage is their availability in almost limitless shapes and in extreme complexity. Sand castings can be extremely large, but there is a practical limit to their minimum size. The process is not recommended for thin-section castings.

When moderate quantities of a part are required, sand castings can be relatively inexpensive, despite the hand labor required. Practically any metal can be used, with the exception of the newer metals which react with air while in the molten state. For precision parts, sand castings are usually restricted to the light alloys and certain bronzes.

Precision sand castings. Higher accuracy in sand castings is attributable to foundry techniques and closer control over the variables rather than a change in process. Carefully constructed baked sand cores are used when this accuracy is specified, whereas normal green sand molds are used elsewhere.

Most precision sand castings are formed of aluminum and magnesium alloys and the phosphor and tin-bearing bronzes. The as-cast mechanical properties of these castings are approximately the same as those found in conventional sand castings.

Shell mold castings. These castings are formed of any alloy that can be cast in sand, though some casting alloys may be more difficult than others. The low carbon steels tend to have surface defects. Sweating of tin and lead in brasses and bronzes containing a high percentage of these alloying elements has caused problems. The reactivity of magnesium with oxygen and silica sand must be countered with inhibitors or mold washes.

Mechanical properties are comparable to, or better than, those of sand castings. Closer control can be exercised. Since the shell mold is baked dry, the lack of moisture slightly increases the insulating effect of the mold; the resulting slower cooling of the metal produces better uniformity of structure. The high permeability of shell molds minimizes porosity and voids in the solidified metal by allowing air and gases generated during pouring to escape through the shell.

Permanent mold castings. Parts must be of relatively simple design, but some complexity is possible by using sand cores with steel molds (semipermanent molding). Because of the relatively low temperature limit of the mold material, the process is limited to the lower melting alloys. Aluminum alloys are the most commonly cast. Copper-base alloys, magnesium and, more recently, gray iron are also cast in permanent molds.

Permanent mold castings are usually dense and fine-grained, and can be made with better surfaces

GENERAL CHARACTERISTICS OF CASTINGS

Type ⬇	Cost				Time[c]	Size			As-Cast Finish, rms[e]
	Labor	Equipment[a]	Material	Typical Pouring Rate, per hr[b]		Range	Avg, lb[d]	Min Section Thk, in.	
Sand	High	Die low, tooling high, pattern ¼ of die	Low	25	3–15 days	<1 oz to >200 tons	Few ounces to several tons	Special—1/16, small—3/32–1/8, large—3/16–¼	Requires grinding, polishing, buffing
Precision Sand	Medium high	Low	High	300 per month	4–6 weeks	Max size not known. Present — <1 lb weight to 6 ft length	1–4	0.050	75–80
Permanent Mold	Medium	High	Nonferrous—high, gray iron—low	30	6–12 weeks	1 oz to 600 lb	1–10	0.090	100–125
Plaster Mold	Medium high	Low	High	4–5	4–6 weeks	<1 oz to >100 lb	3–5	0.040–0.060	50
Investment	High	Varies with quality of pattern die necessary	Wide range	Generally low; higher with plastics pattern	4–6 weeks	<1 oz to 25 lb —wax or plastics; >100 lb—frozen mercury	Up to 1	0.030	60—wax and plastics; 40—mercury
Die	Low	High	High	75–150 aluminum, magnesium, copper-base; 300–350 zinc	8–14 weeks	<1 oz to 75 lb aluminum; <1 oz to 200 lb zinc	½–1	0.050	50

[a] Dies, patterns and/or machines.

[b] These figures are general for one set of equipment. Actual rate of casting production depends on number of cavities per mold.

[c] From complete design to production.

[d] Average size of competitive castings.

[e] Finish obtainable in limited areas.

and closer tolerances than sand castings. Molds may be preheated to the 700-800 F range to achieve high control. Tolerances must be wider than for die castings, shell mold castings and plaster mold castings.

Plaster mold castings. These castings are noted for their fine finishes which reflect the smoothness of the plaster in which they are cast. The insulating quality of the mold causes a slower cooling rate which results in a reduction of tensile strength and elongation. Although plaster mold castings are used for some high production parts, they are usually considered for small to medium-sized lots. Molding costs are relatively high, but these costs are usually recovered because of the minimum of machining.

Because of the temperature limitations of the mold material, this method is restricted to casting alloys with a melting point below 2000 F. These include aluminum, magnesium, and some of the copper-base alloys, such as yellow brass, silicon bronze, beryllium bronze, aluminum bronze and manganese bronze. Some foundries restrict lead content to 1.5% because of the reactivity of lead with plaster; others claim to have cast 50% lead alloys without difficulty. Alloys containing silicon lend themselves to finer detail with better surface finish. When casting magnesium, special plaster compositions and handling techniques are required, as well as more ample feeding facilities in the mold.

Centrifugal castings. Parts are limited in size and shape, but for large runs there are cost advantages in the elimination of risers or feedheads and of cores in cylindrical shapes. Parts have a dense metal structure with impurities forced back to the center where they can be machined out. Any metal can be cast by this process, and the pressure exerted means that sections can often be thinner than if cast by static methods. A disadvantage is that heat transfer to walls of metal molds and to the center air space must be controlled. For this reason the mold cavity is sprayed with sand or a refractory coating. Limiting dimensions for cylinders are lengths up to 347 in. and diameters from 2 to 50 in. Tolerances are of the same order as in other close tolerance casting methods.

The centrifugal casting method—rotating the mold as the metal solidifies—has three variations: (1) true centrifugal casting—mold is rotated about its horizontal or vertical axis; used for mass production of pipe, large gun barrels and liners, cylinder liners, brake drums and aircraft engine cylinders; (2) semi-centrifugal casting—centrifugal force causes molten metal to flow from a central feeding reservoir into one or more sand molds rotated about their central axis; used primarily for wheels; (3) centrifuging—low rotational speeds are used and the castings need not have axes of rotation but are spaced about a central feed reservoir; used for nonsymmetrical objects such as bearing caps and small brackets.

Investment castings. These parts are formed using a pattern molded in wax, plastic, or frozen mercury. Each pattern type has characteristics that make it more suitable for certain parts. Wax permits the greatest flexibility of design and is the least costly. Plastics permit more rapid production of patterns and also allow a surplus of patterns to be stored for future use. Frozen mercury allows larger sizes to be cast and requires only a thin ceramic shell which, in turn, results in better metal quality. In general, investment cast parts offer dimensional tolerances superior to those of other castings, can be made in shapes too complex for metal powder parts, and can be made of metals with melting points too high for die casting. Mechanical properties are generally high.

Of the seven types of close tolerance castings (i.e., excluding sand castings), investment castings are matched only by shell moldings and centrifugal castings in the range of castable alloys available. These alloys include high melting ferrous alloys, copper alloys, special high temperature nonferrous alloys, and all castable aluminum and magnesium alloys.

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MACHINE FINISH ALLOWANCES

Metal ⬇	Pattern Size, in.	Bore, in.	Finish, in.
Cast Iron	Up to 12	1/8	3/32
	13 to 24	3/16	1/8
	25 to 42	1/4	3/16
	43 to 60	5/16	1/4
	61 to 80	3/8	5/16
	81 to 120	7/16	3/8
	Over 120	[g]	[g]
Malleable Iron[a, b, c, d]	Up to 6	1/16	1/16
	6 to 9	3/32	1/16
	9 to 12	3/32	3/32
	12 to 24	5/32	1/8
	24 to 35	3/16	3/16
	Over 36	[g]	[g]
Steel[e]	Up to 12	3/16	1/8
	13 to 24	1/4	3/16
	25 to 42	5/16	5/16
	43 to 60	3/8	3/8
	61 to 80	1/2	7/16
	81 to 120	5/8	1/2
	Over 120	[g]	[g]
Brass, Bronze, Aluminum[f]	Up to 12	3/32	1/16
	13 to 24	3/16	1/8
	25 to 36	3/16	5/32
	Over 36	[g]	[g]

[a] When castings are constructed so that they warp more than the average amount, the allowances given should be increased.

[b] Disk grinding—only sufficient finish required to take care of draft and possible warpage.

[c] Coin pressing—practically no finish allowance required.

[d] For small parts, an allowance of 1/32–1/16 in. is satisfactory. Larger parts require a slightly greater allowance.

[e] Allowance ranges from 1/8 to 1 in. Values given for finish are normal for ordinary finishes on the drag side. For finished surfaces on the cope side, it is often necessary to double the allowance.

[f] For small or medium-sized nonferrous castings, 1/8 in. is a customary allowance, with correspondingly larger allowances on larger castings,

[g] Special instructions.

Castings—concluded

Though the same general degree of accuracy is obtainable with all alloys, it is easier to obtain with the nonferrous alloys because of their higher fluidity and lower melting points.

Die castings. Only nonferrous alloys are suitable for die castings. The range of these alloys is adequate for most needs but more limited than for sand castings. Alloys used, in order of tonnage, are: zinc, aluminum, copper, magnesium, lead and tin. They can be grouped in low and high melting classes according to melting point:

Low melting alloys	
Zinc	727 F
Lead	484 F
Tin	417 F

High melting alloys	
Aluminum	1115 F
Magnesium	1110 F
Copper	1600 F

The high melting group are usually cast in cold chamber or air injection machines; the low melting alloys in plunger machines. Of all casting processes, die casting is by far the best suited to high production of quality parts. As in permanent mold casting, an advantage is derived from the high thermal conductivity of the steel used in the die. The resultant chilling effect promotes fine grained metallurgical structure. Though die castings are subject to varying degrees of porosity, proper engineering of the casting and die may confine it to noncritical areas.

Design Factors

Draft allowances. Draft allowance is normally at least ½ in. per ft., although it often ranges from ¼ to ⅜ in. per ft. It is seldom less than 1 deg and ⅛ in. per ft. In sand and plaster mold casting, the mold is destroyed; therefore the draft required is only necessary to remove the pattern. Investment casting requires no draft, though ½ to 1 deg can be specified for single parting, noncored dies. Frozen mercury, wax and plastics patterns require no draft, but ½ deg is used with Kirksite dies.

Permanent mold—A minimum of 2 deg on each side is usually provided, though the range is 0 to 3 deg. In recesses, 2 deg on each side is a minimum with 5 deg desirable. The following figures (in. per in. of depth on one side) are fairly standard: magnesium—0.015, aluminum—0.015, bronze—0.020.

Shell mold—Draft angles are not as critical as for permanent mold castings. From ¼ to ½ deg is

DIMENSIONAL TOLERANCES (In.)[a]

Sand Castings	
Gray Iron	1/32–1/16
Malleable Iron	3/32
Steel	5/32
Aluminum Alloys	5/64
Magnesium Alloys	11/64
Brass	3/32
Bronze	1/8
(Zinc, tin, lead not cast)	
Shell Mold Castings	
Ferrous	0.001–0.003 in./in. possible. Commercially 0.010 to 0.015 are held on dimensions within mold half. Across parting line: 0.020–0.030
Magnesium, Others	Same as ferrous
(Zinc, tin, lead not cast)	
Permanent Mold Castings	
Aluminum	0.015 for first inch; then 0.002 in./in. Common total: 0.010–0.050
Magnesium, Gray Iron, Others	Same as aluminum or slightly wider
(Steel, tin not cast)	
Plaster Mold Castings	
Brass, Bronze	0.005 for first inch; then 0.001 in./in. Common total: 0.005 to 0.010
Aluminum, Others	Same as brass and bronze
(Ferrous, zinc, tin, lead, copper not cast)	
Investment Castings	
Copper	0.002–0.005 in./in.
Stainless Steel	0.004–0.008 in./in.
Others	0.003–0.006 in./in.
(Iron, some steels, zinc, tin, lead not cast)	
Die Castings	
Zinc	0.0025 for less than 1 in. 0.001 in./in. for dimensions greater than 1 in.
Aluminum, Magnesium	0.003 for less than 1 in. 0.001–0.002 in./in. for dimensions greater than 1 in.
Others	0.005 for less than 1 in. 0.003 in./in. for dimensions greater than 1 in.
(Ferrous not cast)	

[a] Tolerances are for usual commercial practice, stated for guidance only. In most cases closer tolerances can be held at increased cost. Tolerances are over-all unless stated as in. per in. All values are ± tolerances.

usually sufficient for shell mold castings.

Die—In general, a minimum of 2 deg per side is usually provided. The following draft tolerances (in.) are usually provided:

Magnesium	0.010[a]
Aluminum	0.010-0.015
Zinc	0.005-0.007
Brass, bronze	0.015-0.020
Tin, lead	0.015

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[a] In. per in. of depth, one side.

Shrinkage allowances. The following allowances (in. per ft) are usually provided:

Cast iron	1/8
Malleable iron	1/8
Steel	1/4
Aluminum	5/32
Brass	3/16

Design Rules

1. Stress concentration is always a vital consideration. A larger amount of metal will have greater shrinkage and put an adjoining thin section under tension which may result in cracking. The design should incorporate fillets when there is a change of section thickness or to avoid sharp, interior corners. In addition to lowering stress concentration, fillets help achieve even cooling and shrinkage.

2. Continuous, intersecting ribs may cause trouble. Staggering the ribs will help prevent the build-up of high stresses.

3. Avoid large, flat areas with little or no support.

4. The parting line, particularly in die castings, is preferably located at the corner of the casting. Lines of demarcation remaining after flash removal will not be nearly as visible.

MINIMUM SECTION THICKNESS (In.)[a]

Sand Castings	
Gray Iron[a]	1/8–3/16
White Iron	1/8–3/16
Malleable Iron	1/8–3/16
Steel	3/16–1/4
Aluminum	1/8–3/16
Magnesium	3/16–1/4
Brass, Bronze	3/32–1/8
Shell Mold Castings[b]	
Ferrous	1/16–1/8
Magnesium, Others	1/16–1/8
Permanent Mold Castings	
Aluminum	
< 3 In.	3/32–1/8
3 to 6 In.	5/32
>6 In.	3/16
Gray Iron, Others	
<3 In.	3/32–1/8
3 to 6 In.	5/32
>6 In.	3/16
Plaster Mold Castings	
Brass, Bronze	
2 Sq In.	0.040
4 to 6 Sq In.	0.063
<30 Sq In.	0.093
Aluminum, Others	
2 Sq In.	0.040
4 to 6 Sq In.	0.063
<30 Sq In.	0.093
Investment Castings[b]	
Copper	0.030
Stainless Steel	0.050
Others	0.030
Die Castings	
Zinc	
Small	0.020–0.030
Large	0.050
Aluminum	0.035
Magnesium	0.050
Aluminum Alloy	
Small	0.045–0.055
Large	0.080
Magnesium Alloy	
Small	0.050–0.060
Large	0.080
Copper	
Small	0.06
Large	0.10
Brass, Bronze	0.050
Tin	
Small	0.030
Large	0.060
Lead	
Small	0.040
Large	0.070

[a] Usual minimum for various classes of gray iron is: class 20, 1/8; class 25, 1/8; class 30, 1/4; class 35, 3/8; class 40, 1/2; class 50, 1/2; class 60, 3/4.

[b] Avoid section differences where max : min ratio is more than 5 : 1.

Extrusions

General

Extrusions are used extensively as a means of making small parts of uniform cross section that might otherwise be made only through extensive machining. Long pieces of the desired cross section are extruded, then cut to desired lengths and subjected to any further operations that may be required.

Advantages. Extruded shapes are not considered to be highly precise as far as dimensional tolerances are concerned, but they do have the advantage of permitting the metal to be placed where it is most needed to attain desired strength and design characteristics. Relatively complex shapes can be extruded. Sharp corners and reentrant angles are readily obtainable. When precision is a requirement, final dimensions are achieved through machining. Extruding is sometimes used to make blanks for other processes, e.g., forging.

Limitations. Sizes are limited because of the excessive size of the presses required to extrude large sections, and because large shapes are likely to bend and distort excessively under their own weight and require expensive straightening operations. Any openings must be in the direction of the extruding action and uniform throughout the entire length of the extrusion.

Materials. Although in the past most extruded shapes have been made from aluminum, magnesium and copper alloys, the process has recently been expanded to include many types of steels. Steels and other high melting alloys are easy to extrude, but they are hard on die materials and require lubricants with special qualities. Titanium, lead, tin and zinc alloys are also extruded. For best results the ratio of billet size to finished extrusion should be large. When large ratios are used, the resulting extrusions are dense, homogeneous and free of porosity, and the metal properties compare favorably with those attained in forging. Ratios usually range from 20:1 to 40:1.

Speed of output. Rate of output of extruded shapes can affect cost, particularly if large quantities are required. Speeds range from 1½ to 700 fpm, depending on the basic material, the particular alloy and the shape being extruded. Magnesium is extruded at speeds of 4 to 100 fpm, aluminum somewhat faster, and copper alloys a little slower. Highest speeds are attained with nickel alloys and steels.

Applications. Conditions under which extruded shapes might be chosen are:

1. When a more efficient disposal of metal is desirable than is obtainable with rolled shapes or other metal forms.
2. Where several parts are now joined to provide a small assembly.
3. Where shapes are required that could not be obtained without difficult machining.
4. Where short pieces of an extrusion could replace small castings or forgings.

Design Factors

Tolerances. Tolerances on extruded metal parts are held on such factors as straightness, flatness, twist, section thickness, angles, contours, and corner and fillet radii.

Flatness—On a 6-in. width, tolerance would be ±0.024 in., or about 0.004 in. per in. of width.

Straightness—On a 5-ft length, a 1/16-in. deviation from a straight line is normal. This deviation increases to ⅜ in. at 30 ft.

Cross section—Typical are tolerances ranging from ±0.006 in. on thicknesses of less than 0.125 in. up to ±0.080 in. on thicknesses or widths of 14-15 in.

Cut ends—Permissible deviation from the square is 1 deg.

Curved surfaces—Allowable deviation from a specified contour is 0.005 in. or 0.004 in. per in. of chord length, whichever is greater. This tolerance does not apply to an arc of more than 90 deg.

Section thickness. Thickness of sections usually ranges from 0.050 in. up to several inches. Ratios of thickness to width vary with materials used and are standardized for aluminum and magnesium extrusions. Aluminum alloys, such as 3003 and 6063 have a ratio of 8 in. wide to 3/32 in. thick; for 2014, it is 8 in. wide to ⅛ in. thick.

Design Rules

1. Extruded shapes are usually restricted to those that can be contained within a circumscribing 17-in. circle. Within this range, parts can be made as solid, hollow or semihollow shapes; T, L or V sections; rectangles; and complex shapes.
2. Avoid extremely thin sections within a large circumscribing area.
3. Avoid semihollow sections with unbalanced die tongues.
4. Avoid sections with extreme thickness variation.
5. Avoid hollow shapes having unsymmetrical voids or inadequate thickness between voids.

Stepped Extrusions

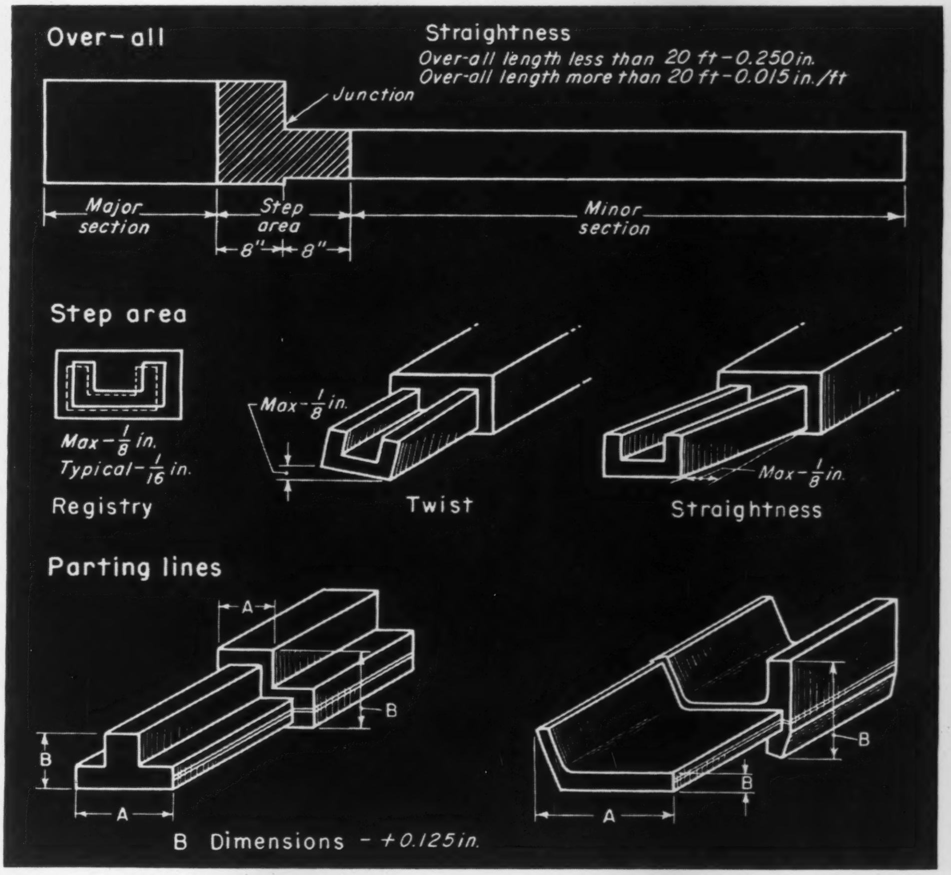
Stepped extrusions are commonly produced by utilizing two sets of extrusion dies.

In designing a stepped extrusion it is important to use dimensional tolerances that are realistic, yet avoid an excess of stock. Stepped extrusion tolerances have not been standardized, but those given in the accompanying sketches are typical. Straightness tolerances differ from those for normal extrusions. In addition, special tolerances apply to the step area and across the parting line when split dies are used.

Because of the inherent instability of split dies, cross section tolerances of stepped extrusions are usually greater than for normal extrusions. In locating parting lines, it is important to consider not only tolerances but also the ability to remove tools from the section. It is sometimes necessary to provide slight draft angles on extended elements.

Although the major and minor sections may frequently have a common plane, this is not a requirement of the process. In all cases, however, the major section must completely enclose the minor section. It is generally necessary to provide machining stock on all surfaces to obtain the required dimensional accuracy and surface finish.

Straightness of the over-all part is measured by deviation from a reference line, the junction or step area (8 in. on either side of the step) being excluded. Straightness of the minor or major portion of the extrusion is determined individually. Because of the difference in flow conditions in extruding the major and minor sections, the junction area usually presents the greatest straightening problems. Minor and major portions are usually furnished to standard extrusion straightness tolerances.


Over-all
Straightness
Over-all length less than 20 ft - 0.250 in.
Over-all length more than 20 ft - 0.015 in./ft
Junction
Major section
Step area
Minor section
8"
8"
Step area
Max - 1/8 in.
Typical - 1/16 in.
Registry
Max - 1/8 in.
Twist
Max - 1/8 in.
Straightness
Parting lines
A
B
B
A
B
B
A
B Dimensions - +0.125 in.

Impact Extrusions

General

Parts made by impact extruding cannot be very large or very small. They must be concentric in design, but can be provided with lugs, flutes and similar projections. Mechanical properties of impact extruded parts are usually high because of the tremendous amount of cold work involved in the process; this is particularly true of carbon steels.

Often a concentric impact extrusion is sectioned after forming to make two or more parts which could not otherwise meet the design requirements of impact extrusion. Examples are semicircular and U-shaped pieces.

Comparisons. Both impact extrusion and deep drawing use a combination of punch and die to form a hollow shell from a cold blank, and for some parts equivalent speeds are used. The difference lies in the manner in which deformation occurs. In impact extrusion the metal is forced through an orifice between punch and die under compressive stresses; in deep drawing the metal is pulled into the die by the punch and stressed in tension.

Both impact extrusion and ordinary extrusion force metal through a die under compressive stresses. However, the metal is generally cold worked in impact extrusion and hot worked in ordinary extrusion. In addition, impact extrusion produces a single component that may or may not require further operations, whereas ordinary extrusion generally produces a continuous cross section such as a rod, tube or structural shape.

An impact extruded part can be considered as a modified forging in which the flash forms the side walls. The part has a base that, in backward extrusion at least, is a forging, and side walls that are extrusions.

Advantages.

1. High speed production is possible.
2. Unit cost of mass produced parts is low.
3. Materials saving and excellent metal recovery are achieved.
4. Process requires few operations. Ribs, fins, holes, etc., are formed during extrusion.
5. Parts have dimensional uniformity with close diametrical tolerances.
6. Tooling is relatively cheap.
7. Surface finishes on the order of 20 to 70 microinches are obtainable.
8. Bottom thicknesses are independent of wall thicknesses.
9. Parts can be made with zero draft angles and sharp corner radii.
10. Parts have excellent properties; for example, cold formed low or medium carbon steel parts have mechanical properties equivalent to those of heat treated carbon and low alloy steels.

COMMERCIAL SIZE RANGES FOR ALUMINUM IMPACT EXTRUSIONS

Material	Wall Thickness, in.		Diameter, in.	
	Max	Min	Max	Min
1070 (collapsible tubes)...	0.010	0.0035	2½	⅜
1100, 3003..............	½[a]	0.010	6	¾
Medium Strength Alloys..	½[a]	0.040	5	¾
High Strength Alloys.....	½[a]	0.062	4	¾

[a] Some authorities state that the maximum wall thickness is "not known."

Limitations.

1. Relatively few alloys can be processed commercially at present.
2. Shapes that can be produced are limited.
3. Length-to-diameter ratio is restricted.
4. Maximum size of part is limited by press capacity.
5. Comparatively high equipment costs limit applications to relatively high production runs.

Design Factors

Sizes. Part sizes and dimensional tolerances vary considerably, depending upon the metal. Some typical figures: in aluminum, wall thickness ranges from a maximum of ½ in. down to 0.010 in. in the soft alloys or 0.062 in. in the stronger alloys. Diameters of parts can be as great as 6 in. in the soft alloys and 4 in. in the hard alloys, and as small as ¾ in. Larger parts would require extremely high pressures, and smaller parts would involve excessive tool damage.

Tolerances. Typical commercial dimensional tolerances for aluminum are as follows. On walls as thin as 0.10 in., the tolerance can be held to 0.010 in. Over 0.15 in., the tolerance must be increased to 0.020 in. Diameters can be held to 0.010 in., but lengths are not usually guaranteed any closer than 3/16 in.

Materials. By far the most commonly used material for mechanical parts is aluminum and its alloys. More than a dozen different alloys are used, depending upon the end service requirements, but from the standpoint of extruding 1100 alloy is best.

In steels, best results are obtained with those containing up to 1.2% carbon, although several alloy steels are impact extruded regularly. Steel parts must be somewhat smaller and have greater wall thicknesses than similar parts in aluminum.

Magnesium slugs are heated to 500 to 700 F for impact extruding. Several different alloys can be used, but best results are obtained with alloy AZ31B.

Several other metals are impact extruded to a lesser degree. They include lead, tin, copper, zinc and zirconium.

Fabricated Sheet Metal Parts

Stampings and Press Formed Parts

General. Blanking, piercing, drawing, bending, ironing and coining are all done on hydraulic or mechanical presses, or on drop hammers. The folding up, and sometimes the piercing, of long shapes is done on press brakes. Wrap-around operations on small parts are done on multislide machines. Large quantities of drawn parts are made in eyelet or transfer presses with multiple stations.

Stampings which do not require deep draws and which are less than 6 in. in dia and 0.109 in. thick can be made from coil stock by using progressive dies which combine several operations at each stroke. Such costly dies are rarely justified for runs of less than 30,000 pieces. Sometimes duplicates are made side by side.

Advantages and limitations. Parts can be fairly complex in shape, but the extreme-low-cost advantages disappear as increasing complexity adds to the number of operations required. Because of the many variables in stamping design and stamping equipment, the extent of the advantages is greatly dependent on the knowledge and skill of the die designer. Finishes are good, and the parts are generally uniform and nonporous. Limitations include cost of tools, the roughness of sheared edges, and the difficulty inherent in substantially changing original stock thickness.

Materials. Nearly any metal that can be rolled can be used for stampings. Formed and drawn parts are usually made of soft temper materials, but parts can be heat treated after forming. Commonly used: carbon steels, particularly low carbon steels; copper; brass; bronze; aluminum; magnesium alloys; zinc; titanium; nickel alloys; stainless steels; and some alloy steels. A substantial variety of finishes are applied.

Dimensional tolerances. Stampings may be as thin as 0.003 in., or as heavy as ⅝ in., and may vary in size from tiny shapes to freight car ends. Dimensional tolerances vary with the thickness of the material and the size of the part. Tolerances of ±0.001 in. are available on dimensions up to 2 in., tolerances on the order of ±0.003 in. on dimensions up to 6 in. Heavy material calls for more generous tolerances. It is a general rule that when unnecessarily close tolerances are called for, more expensive tooling, higher costs of tool repair, and sometimes extra operations are required.

Design rules. In general, the following design rules apply to all stamping operations:

1. Material can frequently be strengthened by the addition of flanges, beads, corrugations or ribs.

2. Ribs and bosses should be at least four times as wide as deep, so the metal will stretch.

3. Hole edges may be extruded for greater thread length, etc. The depth of such extrusions without gathering operations should not exceed 15 to 20% of hole diameter.

4. Coining can force metal to flow and thus produce locating projections and grooves. This type of operation is particularly applicable to softer materials and smaller parts.

COMPARATIVE FORMABILITY OF METALS[a]

Metal	Alloy	Rating
Aluminum	1100-O	100
	3003-O	95
Magnesium (hot formed)		95[b]
Aluminum	6061-O	92
	5052-O	80
	7075-O	75
	2024-O	75
	2014-O	75
Deep Drawing Steel	1008	75
Zinc		75
Soft Copper		75[b]
Commercial Steel	1010	70
Soft Brass		70
Aluminum (as quenched)	7075-W	60
	2024-W	60
	2014-W	60
Aluminum	1100-¼H	50
Stainless Steel	Type 302	49
	Type 304	46
Aluminum	3003-¼H	45
Stainless Steel	Type 321	43
Aluminum	5052-¼H	40[b]
	1100-½H	40[b]
Titanium		40
Stainless Steel	Type 347	40
Aluminum	3003-½H	35[b]
	5052-½H	30[b]

[a] Based on rating of 100 for 1100-O aluminum.

[b] Tentative.

PENETRATION OF PUNCH THROUGH METAL IN BLANKING OR PIERCING OPERATIONS

Metal ↓	Annealed		Partially Cold Worked	
	Resistance to Shearing, psi	Reduction or Penetration, %	Resistance to Shearing, psi	Reduction or Penetration, %
Lead	3,500	50	—[a]	—[a]
Tin	5,000	40	—[a]	—[a]
Aluminum	8,000	60	13,000	30
Zinc	14,000	50	19,000	25
Copper	22,000	55	28,000	30
Brass	32,000	50	52,000	20
Bronze (90–10)	—	—	40,000	30
Tobin Bronze	36,000	25	42,000	17
Steel				
0.10% C	35,000	50	43,000	38
0.20% C	44,000	40	55,000	28
0.30% C	52,000	33	67,000	22
0.40% C	62,000	27	78,000	17
0.60% C	80,000	20	102,000	9
0.80% C	97,000	15	127,000	5
1.00% C	115,000	10	150,000	2
Silicon Steel	65,000	30	—	—
Nickel	35,000	55	—	—

[a] Anneals at room temperature.

continued on next page

Fabricated Sheet Metal Parts

MINIMUM BEND RADII FOR ALUMINUM SHEET[a]

Gage, in. ↓	7075-O, 7075-W[b]	7075-T6	2024-O, 2024-W,[c] 2014-O	2014-T3	2024-T3, 2014-T6	6061-O
0.020..	1/32	3/32	1/64	1/16	1/16	0
0.025..	1/32	1/8	1/64	1/16	3/32	0
0.032..	1/16	5/32	1/64	1/16	3/32	0
0.040..	1/16	3/16	1/32	3/32	1/8	0
0.051..	3/32	1/4	1/16	1/8	3/16	0
0.064..	1/8	5/16	1/16	5/32	7/32	0
0.081..	5/32	3/8	3/32	7/32	9/32	0
0.091..	3/16	1/2	3/32	1/4	11/32	0
0.102..	3/16	5/8	3/32	5/16	7/16	0
0.125..	7/32	3/4	1/8	3/8	1/2	1/16
0.156..	3/8	1	5/32	7/16	5/8	1/8
0.187..	1/2	1 1/4	3/16	1/2	3/4	3/16

Gage, in. ↓	6061-T4	6061-T6	5052-O	5052-H32 1/4 Hard	5052-H34 1/2 Hard	5052-H38 3/4 Hard
0.020..	1/32	1/32	0	0	0	1/32
0.025..	1/32	1/32	0	0	0	1/32
0.032..	1/32	1/32	0	0	0	1/32
0.040..	1/32	1/32	0	0	0	1/16
0.051..	1/16	1/16	0	0	1/32	1/16
0.064..	1/16	3/32	0	0	1/16	3/32
0.081..	3/32	1/8	0	1/32	1/16	1/8
0.091..	1/8	5/32	0	1/16	3/32	1/8
0.102..	1/8	3/16	0	3/32	1/8	3/16
0.125..	3/16	1/4	0	1/8	1/8	1/4
0.156..	5/16	5/16	0	5/32	3/16	1/2
0.187..	3/8	9/16	0	3/16	9/32	9/16

Gage, in. ↓	5052-H38 Hard	1100-H12 1/4 Hard	1100-H14 1/2 Hard	1100-H16 3/4 Hard	1100-H18 Hard
0.020..	1/32	0	0	0	1/32
0.025..	1/32	0	0	0	1/32
0.032..	1/16	0	0	0	1/32
0.040..	1/16	0	0	0	1/16
0.051..	3/32	0	0	1/32	1/16
0.064..	1/8	0	0	1/16	3/32
0.081..	3/16	1/32	1/32	1/16	1/8
0.091..	1/4	1/16	1/16	3/32	1/8
0.102..	5/16	3/32	3/32	1/8	3/16
0.125..	3/8	1/8	1/8	1/8	1/4
0.156..	5/8	5/32	5/32	3/16	1/2
0.187..	3/4	3/16	3/16	9/32	9/16

[a] Minimum allowable radii for bending aluminum alloy sheet depend on thickness, temper and composition. Values given in the table are for 90-deg bends and should be increased for bends greater than 90 deg.

[b] Freshly quenched and formed within 2 hr max, or 24 hr max if iceboxed at 32 F.

[c] Freshly quenched and formed within ½ hr max, or 24 hr max if iceboxed at 32 F.

MINIMUM BEND RADII FOR MAGNESIUM ALLOY SHEET[a]

Alloy ↓	Forming Temperature, F				
	70	300	400	500	600
M1					
Annealed (M1a)........	5T	4T	3T	2T	1T
Cold Worked (M1h)........	11T	8½T	6½T	4½T	—
AZ31					
Annealed (AZ31Xa)........	3½T	2T	1½T	1T	—
Cold Worked (AZ31Xh)......	7½T	3T			
AZ51X					
Annealed (AZ51Xa)........	6T	4½T	3½T	2½T	2T
Cold Worked (AZ51Xh)......	9T	6½T	4½T		

Experimental values, where T=metal thickness.

MINIMUM BEND RADII
FOR AUSTENITIC STAINLESS STEELS[a]

Annealed........	½T to 1T
¼ Hard........	1T to 2½T
½ Hard........	2½T to 4T
¾ Hard........	3T to 5T
Full Hard........	4T to 6T

[a] Where T=metal thickness.

5. Unless the print calls for parts to be washed, deburred, flat within a given tolerance, or specially handled to reduce any marks, stampers make extra charges for such operations.

Pierced parts. The following design rules should generally be observed:

1. The diameter of a hole is measured by its smallest dimension (the edges of a pierced hole are not straight).

2. Hole diameters should be more than two-thirds of metal thickness (larger in hard materials), and never less than 0.030 in.

3. Distance between hole edges, or hole edge and outside periphery, should be greater than metal thickness. For combined operations, a minimum of 3/32 in. is desirable for the die to stand up.

4. If holes are dimensioned from the edges of parts, they may be pierced in the flat. If they are closely dimensioned from bends, secondary operations are necessary.

5. Holes near a bending edge should be a distance of 1½ times metal thickness, plus bend radius, from formed angle. Long slots should be a distance of four or five times the metal thickness from a formed angle. Sometimes such holes are pierced after form-

BEND ALLOWANCES IN STEEL SHEET[a]

Inside Bend Rad., in. ⬇	Metal Thickness, in.								
	.022	.028	.035	.049	.065	.095	.120	.187	.250
.032	.00072	.00076	.00082	.00093	.00105	.00129	.00148	.00200	—
.0625	.00126	.00131	.00136	.00147	.00160	.00183	.00203	.00255	—
.093	.00180	.00185	.00191	.00202	.00212	.00238	.00257	.00309	—
.125	.00235	.00240	.00245	.00256	.00269	.00292	.00311	.00364	—
.156	.00289	.00294	.00300	.00311	.00323	.00346	.00366	.00418	—
.1875	.00344	.00349	.00354	.00365	.00378	.00410	.00420	.00473	—
.218	.00398	.00403	.00409	.00419	.00432	.00455	.00475	.00527	—
.250	.00453	.00458	.00463	.00474	.00487	.00510	.00529	.00582	—
.281	.00507	.00512	.00517	.00528	.00541	.00564	.00584	.00636	—
.3125	.00562	.00567	.00572	.00583	.00596	.00619	.00638	.00691	—
.343	.00616	.00620	.00626	.00637	.00650	.00673	.00693	.00745	—
.375	.00671	.00675	.00681	.00692	.00705	.00728	.00747	.00800	.00849
.406	.00725	.00730	.00735	.00746	.00759	.00782	.00802	.00854	.00903
.4375	.00780	.00784	.00790	.00801	.00813	.00837	.00856	.00908	.00958
.468	.00834	.00839	.00844	.00855	.00868	.00891	.00911	.00963	.01012
.500	.00889	.00893	.00899	.00910	.00922	.00945	.00965	.01017	.01067
.531	.00943	.00948	.00953	.00964	.00977	.01000	.01019	.01072	.01123
.5625	.00998	.01002	.01008	.01019	.01031	.01055	.01074	.01126	.01175
.593	.01052	.01055	.01061	.01072	.01084	.01108	.01127	.01179	.01230
.625	.01106	.01111	.01117	.01128	.01140	.01161	.01183	.01235	.01284
.656	.01161	.01166	.01171	.01182	.01194	.01218	.01237	.01289	.01339

[a] Allowance for 1 deg of bend; multiply value in table by number of degrees in bend.

BEND ALLOWANCES IN ALUMINUM ALLOY SHEET[a]

Inside Bend Rad., in. ⬇	Metal Thickness, in.								
	.020	.025	.032	.040	.051	.064	.081	.091	.128
.032	.00070	.00074	.00079	—	—	—	—	—	—
.0625	.00125	.00129	.00135	.00140	.00149	.00159	—	—	—
.093	.00179	.00183	.00188	.00195	.00203	.00213	.00226	.00234	—
.125	.00234	.00238	.00243	.00249	.00258	.00268	.00281	.00289	.00317
.156	.00288	.00292	.00297	.00304	.00312	.00322	.00335	.00343	.00372
.1875	.00342	.00347	.00352	.00358	.00367	.00377	.00390	.00398	.00449
.218	.00397	.00401	.00406	.00412	.00421	.00431	.00444	.00452	.00481
.250	.00451	.00455	.00461	.00467	.00476	.00486	.00499	.00507	.00535
.281	.00506	.00510	.00515	.00521	.00530	.00540	.00553	.00561	.00590
.3125	.00560	.00564	.00570	.00576	.00584	.00595	.00608	.00616	.00644
.343	.00615	.00619	.00624	.00630	.00639	.00649	.00662	.00670	.00699
.375	.00669	.00673	.00679	.00685	.00693	.00704	.00717	.00725	.00753
.406	.00724	.00728	.00733	.00739	.00748	.00758	.00771	.00779	.00808
.4375	.00778	.00782	.00787	.00794	.00802	.00812	.00826	.00834	.00862
.468	.00833	.00837	.00842	.00848	.00857	.00867	.00880	.00888	.00917
.500	.00877	.00891	.00896	.00903	.00911	.00921	.00935	.00943	.00971
.531	.00942	.00946	.00951	.00957	.00966	.00976	.00989	.00997	.01051
.5625	.00996	.01000	.01005	.01012	.01020	.01030	.01043	.01051	.01080
.593	.01051	.01055	.01058	.01065	.01073	.01083	.01098	.01105	.01133
.625	.01105	.01109	.01114	.01121	.01129	.01139	.01152	.01160	.01189
.656	.01160	.01164	.01170	.01175	.01183	.01193	.01207	.01214	.01245

[a] Allowance for 1 deg of bend; multiply value in table by number of degrees in bend

Fabricated Sheet Metal Parts

DIMENSIONAL TOLERANCES FOR DRAWN PARTS (In.)

Thickness, in.[a] ↓	Up to 2 In. Dia	Up to 6 In. Dia
1/32	±0.005	±0.008
1/16	±0.006	±0.010
3/32	±0.008	±0.012
1/8	±0.010	±0.015
1/4	±0.015	±0.020

[a] Gage thickness of round shell to be drawn to height of 1/2 to 3/4 shell dia. Tolerances on irregular shapes are 20% higher.

RECOMMENDED MAXIMUM REDUCTIONS IN DRAWING (%)[a]

Low Carbon Steel	45
Austenitic Stainless Steels	50
Copper	45
High Brasses (70–30, 63–37)	50
Tin Bronze	50
Aluminum (annealed, ¼ hard)	45
Aluminum Alloys	
Annealed, 5052 (¼ hard)	45
Heat Treatable, As Quenched	40
Zinc	40

[a] Ratio of inside cup diameter to blank diameter.

PERMISSIBLE STRETCH IN STRETCH FORMING THIN-WALLED SECTIONS (%)

Aluminum Alloys	
2024-O, 7075-O	10
2024 (-O, -T or as quenched)	6[a]
6061-O, 5052-O	25
Austenitic Stainless Steels (type 301)	
Annealed	20[b]
¼ Hard	15–20
½ Hard	5–10
¾ and Full Hard	2

[a] Up to 10% in the web.
[b] Up to 30% for symmetrical and rigid sections.

ing, in which case a minimum of 3/32 in. for die wall is required.

Formed parts. The following design rules may be applied to formed parts:

1. The height of a formed projection should be greater than 1½ times material thickness, and preferably over ⅛ in. min.

2. Bends in metals which are not soft should be made at right angles to the grain or rolling direction of the metal.

3. Because of springback, which varies with materials and tempers, angular tolerances of at least one deg are necessary (more on short projections).

4. Minimum radii obtainable in a single operation are shown in the accompanying tables.

Drawn shapes. In drawing or forming the force applied exceeds the elastic limit of the metal without exceeding its tensile strength, causing permanent deformation.

1. When deep draws are required (i.e., cup diameter is less than 40% of blank diameter) not only are successive draws required, but it is often necessary to anneal the metal between draws.

2. On shallow draws, radii at the bottom of the drawn shape are usually three or four times the thickness of material, and radii under flanges are four to six times the thickness of material. Large flanges make it difficult to gather metal from the outside of the blank, and several operations may be needed to achieve a comparatively shallow draw.

3. Additional operations will produce a wider range of radii, and a flatter bottom on drawn parts.

4. The punch should cover about 60% of the blank area in any single draw. This means a ratio of depth to diameter of about 45%.

5. Unless a drawn part with variation in height of ±10% of depth is satisfactory, the part will have to be trimmed. Pinch trimming can be combined with other operations, but leaves a sharp edge.

6. The bottom of a cup cannot be drawn thinner than the side walls, but ironing can make cup walls 15% thinner than the bottom. Side walls may also be partially ironed to give steps.

7. Square or rectangular drawn shapes are more costly to tool.

8. Deep parts usually require a draft of 0.0005 to 0.0025 in. per in.

9. I.d. tolerances are affected by draft and out-of-roundness; dimensions thus affected are averaged in determining whether a part meets specified tolerances.

10. Drawing slant-wall shapes, like cones, calls for a greatly increased number of operations and should be specified only when vitally necessary.

11. If aluminum, zinc, or copper drawn symmetrical shapes are required, consider impact extrusions made in presses.

Roll Formed Shapes

Roll formed shapes have been produced from material ½ to ¾ in. thick, but usually the material used in roll forming is less than 0.125 in. thick. Roll forming machines are capable of handling sheet and strip varying in width from a fraction of an inch up to as much as 80 in., though most shapes are made from material less than 20 in. wide.

Dimensional tolerances must be comparatively liberal, primarily because of variations in the thickness of the raw material. Usually dimensional tolerances of ±0.002 in. must be allowed.

Short Run, Press Formed Parts

In the past, stampings and press formed parts could only be considered when huge quantities of parts were required. During the past few years, however, new techniques have been developed to extend the advantages of press forming to relatively small quantities of parts. These methods utilize soft die materials (which are easily worked but have short service lives), rubber blankets, or flexible punches or dies. These materials reduce die costs sufficiently to permit amortization of costs over comparatively small quantities of finished shapes.

RECOMMENDED LIMITATIONS FOR RUBBER PAD FORMING

Metal →	Heat Treatable Aluminum Alloys		Austenitic Stainless Steels	
	O	-T	Annealed	¼ Hard
Max Sheet Thickness, in.	0.187	0.064	0.078	0.032
Recommended Flange Width (straight, not >90 deg), in.[a]	1/16+ 2.5 T	⅛+ 4 T	3/16+ 4.5 T	⅝
Max Metal Thickness for Forming Flanges, in.				
Stretch Flanges	0.125	Special methods required	0.050	0.016–0.030
Lightening Hole Flanges	0.125	0.064	External 0.060, internal 0.050	External 0.040, internal 0.030

[a]T=metal thickness.

PERMISSIBLE STRETCH IN PRESS-DIE AND HYDROPRESS RUBBER FORMING STRETCH FLANGES (%)

Aluminum Alloys	
2024 (-O or as quenched)	18[a], 12[b]
7075 (-O or as quenched)	18,[a] 12[b]
2024-T	12[a], 8[b]
7075-T	7[a]
6061-O, 5052-O	30
Stainless Steels	
301, 302, 304, 305, 308 (annealed)	40
321, 347, 316, 330 (annealed)	30
301, 302 (¼ hard)	25
301, 302 (½ hard)	10

[a]Routed edge. [b]Sheared edge.

Rubber pad. In the rubber pad or Guerin process, a rubber block or pad in the head of the press is used as the second die member to form a sheet metal blank around a punch or form block.

Flexible female die. One method is typified by the Hydroform press, which uses a flexible diaphragm covering a cavity filled with hydraulic fluid. The other method, the Marform press, utilizes a solid rubber pad which holds the blank, while regulated hydraulic pressure allows the punch to move into the pad, forming the part.

Flexible punch. Water or soluble oil is used as the male die member to force the sheet metal to conform to the configuration of the female die.

Drop hammer forming. Zinc-base alloys and lead are normally used for the dies since their low melting points permit rapid and economical fabrication of tools. In simple drop hammer work, there is no hold-down force on the blank; therefore, commonly encountered shapes have flanges and shallow depressions rather than drawn recesses. Parts are formed rather than drawn. Relatively deep draws can occasionally be accomplished with auxiliary devices and fixtures. Reverse contours and saddleback shapes are particularly difficult to form with a drop hammer.

RECOMMENDED SINGLE DRAW LIMITATIONS FOR MARFORM PROCESS

Cup Dia, in. ↓	Max Depth of Draw at Indicated Pressure, in.		Min Thickness, in.
	6000 psi	12,000 psi	
1	⅓	¾	0.008
2	⅔	1½	0.010
3	1	2¼	0.015
4	1⅓	3	0.020
5	1⅔	3¾	0.025
6	2	4½	0.030
7	2⅓	5¼	0.035
8	2⅔	6	0.040

MAXIMUM CUP DEPTH IN MARFORM PROCESS[a]

Metal Thickness, in. ↓	Max Cup Depth, in.
0.064	5⅛
0.050	4⅞
0.037	4¾
0.032	4½

[a]Based on reduction from 12-in. dia blank to 4¼-in. dia cup, 15,000 psi forming pressure.

Patterned Sheet Metal

Type ➔	Coined	Embossed	Perforated	Expanded
How Obtained	Cold rolling with male or female pattern engraved on hardened, forged steel roll and impressed on one side of sheet only	Cold rolling with male pattern engraved on one steel roll and matching female pattern on other, i.e., pattern is impressed three-dimensionally	High speed stamping or punching operation	Spitting and cold drawing in continuous patterns
Advantages	Hide marks, blemishes, scratches; reduce friction on slides, etc.; less costly than Embossed	Advantages of Coined sheet plus increased strength by redistribution of metal (see below); increased surface for heat transfer applications	Allow passage of air and light; visibility for inspection of enclosure; inexpensive	Advantages of Perforated, plus increased strength and possibility of more varied patterns
Remarks	No strong evidence of increased mechanical properties; often used for decorative strip with complex pattern design	Some patterns increase rigidity as much as 108%, impact resistance 39% and yield strength 92%	Mechanical strength decreased; formability increased	Openings can be varied from $\frac{1}{16}$ to 4 in. to suit function and appearance
Materials	Steel, aluminum, stainless steel in sheet and strip. Copper, bronze, brass, nickel silvers in strip	Mostly stainless steel, low carbon steel, and aluminum alloys. Some strip in copper alloys; some titanium	Mostly low carbon steel, aluminum and tin	Aluminum, steel, stainless steel, monel, copper, brass
Sizes	Sheet: 18 to 72 in. x 6 to 24 ft x 0.025 to 0.125 in. Strip: 4 to 6.5 in. x 0.010 to 0.093 in.	5 to 52 in. x 6–16 ft x 0.018 to 0.250 in.	Steel: 16 to 26 gage; 36 x 96 to 48 x 120 in. Aluminum: 14 and 18 gage; 36 x 96 and 36 x 120 in.	14 to 28 gage; 36 x 72 to 48 x 120 in.
Patterns	Unlimited; mostly fluted, pebbled, stippled, ribbed, and stucco. Depth ranges from 0.002 to 0.015 in., generally about 0.007 in.	Large variety; mostly wood or leather grained, diamond, square, and same as coined. Depth ranges from 0.002 into corrugated patterns	Round holes and rounded end slots parallel either to width or length	Almost all diamond-shaped patterns but some woven or wire-fence type patterns
Uses	Decorative applications; materials handling slides; appliance, architectural and furniture trim; jewelry; fish lures	Same as Coined; heat exchangers; fluid transmission units; applications requiring greater strength than Coined	Decorative applications; ventilating panels and covers; guards; baskets; partitions and trim	Same as Perforated; grills; sound absorbent units; enclosures; automotive and aircraft uses requiring strength

"Patterned" is used here to include coined, embossed, perforated and expanded sheet and strip.

Advantages. Essentially the materials are intended for decorative use. In the case of flat sheet metal used over a large area, they prevent kinking and "oil-canning." They also diffuse light, eliminating harsh highlights on polished materials, or telltale highlights on distorted materials. In some cases they provide added strength and rigidity, or allow the use of lighter gage stock. Any changes in mechanical properties depend on the particular process, material and pattern.

Finishes. Most sheet metal products must be finished after fabrication, usually by some type of polishing or coating. The same end result can often be achieved more economically by using patterned sheet instead. Broad decorative and protective possibilities can also be achieved by judicious use of coatings over patterns. Colored textured metal is an outstanding example; the color may be applied by coating with pigment and baking, or by vacuum metallizing.

Design Rules. Patterned metals can be fabricated with standard tooling used for flat sheet metals. Depending on the alloy used, the materials can be blanked, punched, formed, stamped, moderately drawn, roll formed, lock-seam joined, riveted, soldered and welded.

Only for embossed sheet is any modification of standard techniques required:

1. Die clearance should be adjusted for cross-sectional thickness.
2. Bend radii should be at least twice the cross-sectional thickness unless bend lines fall along apexes of the design.
3. For severe bends the axis of bend should run at right angles to the pattern direction.
4. Draws under 1 in. will not usually cause pattern distortion, but actual depth of draw possible depends on pattern.
5. For resistance welding, copper wire braid can be laid between electrode and embossed pattern to form a nest.

Forgings

Cold Headed Parts

General. Cold headed parts are produced in a cold header, essentially a punch press laid on its side. Wire up to about 1 in. in dia is fed into the machine where it is automatically cut to size and positioned in the die with one end protruding from the die face. This end mushrooms out under the force of a punch; the head is formed between the die and punch faces.

Uses. Cold headed parts are economical when mass produced. The majority are mechanical fasteners which are produced at the rate of billions per year by each manufacturer.

Advantages.

1. Grain of the metal follows the contours of the part, avoiding surface weakening.
2. Alloys used are tough, ductile and resistant to cracking.
3. The required corner fillets increase fatigue strength.
4. Surface finish is excellent.
5. No stock is cut away.

Disadvantages.

1. Part must be shaped for extraction from the die.
2. There is a limit to the head volume and shape that can be upset without annealing.
3. Internal stresses may be left at critical points.
4. Size of parts is limited by capacity of cold headers.

Materials. Choice of a metal depends on the heading characteristics of the metal as well as the expected end service. Low and medium carbon steels, some alloy steels and brasses, and some aluminum alloys are most common. Other materials that have been cold headed include: beryllium copper, phosphor bronze, silicon bronze, nickel silver, monel, lead, zinc, silver and gold.

Design Rules

1. Head must taper evenly above and below point of maximum diameter.
2. A widely-spread thin head is more difficult to form.
3. Head heights should be between ¼ and ¾ of wire diameter.
4. Recessed heads require severe forming.
5. Embossing the top of the head increases costs.
6. Concentric heads are easiest to form.
7. Fillets must be provided on corners.
8. Allowable shank reduction is 60% or less.

Tolerances. The best guide to tolerances on cold headed parts are the standards developed by the American Society of Mechanical Engineers for cold headed bolts, screws and rivets. In general, shank diameters are held to ±0.003 in., head dimensions to ±0.005 in., and lengths to ±1/32 in.

Open Die Forgings

Modern open die forging employs mechanical hammers or presses. Each part is heated several times and shaped individually by a highly skilled operator; therefore production rates are low. The major advantages are simplicity of tooling and the wider range of part sizes possible. Shapes are generally simple, and tolerances are much wider than for closed die forgings.

Closed Die Forgings

General. Closed die forgings are produced by shaping hot plastic metal within closed dies; processes include drop, press or upset forging.

Drop forgings—A hammer forces the metal into the die by a series of impact blows. Major advantage is the speed of operation. These forgings are made in weights ranging from less than an ounce to several hundred pounds.

Press forgings—Similar to drop forgings but produced by squeezing in mechanical or hydraulic presses. Particularly adapted to symmetrical parts requiring one or two operations.

Upset forgings—Also produced by squeezing, but the dies grip the stock as well as form the impression. Upset forging is a hot forming process similar to cold heading, but can be used to produce parts weighing from a few ounces up to 500 lb.

Design rules. Dies must shape the part in the easiest possible manner, control the direction of flow, and hold required tolerances. For a large part, several dies may be required. Die blocks are usually made from alloy steel that has been forged to provide uniform properties. Some general design rules are:

1. Divide the impression as equally as possible between the top and bottom dies.
2. Keep the parting line in one plane if possible.
3. Taper the vertical sides to allow removal of the forging.
4. Avoid sharp radii and use fillets where possible.
5. Design ribs as low and wide as possible because they require a corresponding thin pocket in the die.
6. Generous sweeps and maximum draft angles should be provided for sections having a recess because they require that a corresponding raised section be machined into the die. (Raised sections wear rapidly because they get hotter.)
7. Group multiple forgings in die in such a way as to minimize preforming and flash.
8. Where possible, forge two interdependent parts together (e.g., bevel gears and pinions) to reduce die costs and material required.
9. In ring forging, pierce the pancake in such a way that the material removed can be used to produce a smaller ring, thus saving material.

continued on next page

Forgings

SHRINKAGE AND DIE WEAR TOLERANCES[a]

Length or Width, in. ↓	Shrinkage		Max Net Wt, lb ↓	Die Wear	
	Commercial, in. ±	Close, in. ±		Commercial, in. ±	Close, in. ±
1	0.003	0.002	1	0.032	0.016
2	0.006	0.003	3	0.035	0.018
3	0.009	0.005	5	0.038	0.019
4	0.012	0.006	7	0.041	0.021
5	0.015	0.008	9	0.044	0.022
6	0.018	0.009	11	0.047	0.024
For Each Additional Inch Add	0.003	0.0015	For Each Additional 2 Lb Add	0.003	0.0015
For Example:			For Example:		
7	0.021	0.011	13	0.050	0.026
12	0.036	0.018	21	0.062	0.031

[a] Shrinkage and die wear tolerances shall not be applied separately. They shall be applied as the sum of the two and shall be measured in such a way as to eliminate draft or variations in draft. They apply to that part of the forging formed by a single die block, and to no dimension crossing the parting plane.

DRAFT ANGLE TOLERANCES

Type →	Drop Forgings		Upset Forgings	
	Outside, deg	Inside Holes, deg	Outside, deg	Inside Holes, deg
Nominal Angle	7	7 or 10	3	5
Commercial Limits	0–10	0–13	0–5	0–8
Close Limits	0–8	0–8	0–4	0–7

QUANTITY TOLERANCES[a]

No. of Pieces on Order ↓	Over-Run, pieces	Under-Run, pieces	No. of Pieces on Order ↓	Over-Run, %	Under-Run, %
1–2	1	0	100–199	10	5.0
3–5	2	1	200–299	9	4.5
6–19	3	1	300–599	8	4.0
20–29	4	2	600–1249	7	3.5
30–39	5	2	1250–2999	6	3.0
40–49	6	3	3000–9999	5	2.5
50–59	7	3	10,000–39,999	4	2.0
60–69	8	4	40,000–299,999	3	1.5
70–79	9	4	300,000 up	2	1.0
80–99	10	5			

[a] Quantity tolerances shall be the permissible over or under-run allowed for each release or part shipment of an order. Any shipping quantity within the limits of over and under-run shall be considered as completing the order. Commercial and close tolerances shall be the same amounts.

THICKNESS TOLERANCES[a]

Max Net Wt, lb ↓	Commercial, in.		Close, in.	
	Minus	Plus	Minus	Plus
0.2	0.008	0.024	0.004	0.012
0.4	0.009	0.027	0.005	0.015
0.6	0.010	0.030	0.005	0.015
0.8	0.011	0.033	0.006	0.018
1.0	0.012	0.036	0.006	0.018
2.0	0.015	0.045	0.008	0.024
3.0	0.017	0.051	0.009	0.027
4.0	0.018	0.054	0.009	0.027
5.0	0.019	0.057	0.010	0.030
10.0	0.022	0.066	0.011	0.033
20.0	0.026	0.078	0.003	0.039
30.0	0.030	0.090	0.015	0.045
40.0	0.034	0.102	0.017	0.051
50.0	0.038	0.114	0.019	0.057
60.0	0.042	0.126	0.021	0.063
70.0	0.046	0.138	0.023	0.069
80.0	0.050	0.150	0.025	0.075
100.0	0.058	0.174	0.029	0.087

[a] Thickness tolerances for drop hammer forgings apply to the over-all thickness measured in a direction perpendicular to the fundamental parting plane of the dies. For upset forgings, thickness tolerances apply to the metal actually enclosed and formed by the dies, measured parallel to the direction of travel of the ram.

FILLET AND CORNER TOLERANCES[a]

Max Net Wt, lb ↓	Commercial, in.	Close, in.
0.3	3/32	3/64
1.0	1/8	1/16
3.0	5/32	5/64
10.0	3/16	3/32
30.0	7/32	7/64
100.0	1/4	1/8

[a] Fillet and corner tolerances apply to all intersection surfaces, even though drawings or models indicate sharp corners. If such drawings or models have or indicate fillet or corner dimensions of larger radii than these standards, such larger dimensions shall be considered as actually specified and the tolerances shall be "special tolerances."

Where a corner tolerance applies on the meeting of two drafted surfaces, the tolerance shall apply to the narrow end of such meeting and the radius will increase toward the wide end. The total increase in the radius will equal the length of the drafted surface in inches, multiplied by the tangent of the nominal draft angle.

Materials. One of the principal advantages of forgings is the wide range of materials that can be employed. All materials must have these requirements in common: the forging stock (billet, bloom, bar or extrusion) must be hot workable and must be internally sound and free from surface defects. Following is a list of the major classes:

Carbon steels—Low carbon (up to 0.25%) forgings for moderate conditions and for carburized parts where resistance to abrasion is important. Medium carbon (0.30 to 0.50%) forgings for more severe service; some heat treatment is generally desirable. High carbon ($>$ 0.50%) forgings for hard surfaces and springs; heat treatment is essential to obtain other desired properties.

Alloy steels—Manganese, nickel, nickel-chromium, molybdenum, chromium, vanadium, chromium-vanadium, tungsten, silicon-manganese. Forgings from these steels are used wherever higher strength, resistance, durability, etc., are wanted. The proper selection of a particular composition, together with its subsequent heat treatment, depends upon the particular service requirements of the part.

Corrosion and heat resisting, and stainless, steels—These steels are usually high in chromium or nickel, or both. The particular type of corroding agent to be encountered determines the best composition. Generally, but not necessarily, forged surfaces should be polished to obtain full benefit of corrosion resistance properties.

Iron—Wrought iron and ingot iron are forged for special applications where ductility is required. Wrought iron furnishes a moderate degree of corrosion resistance. The copper-bearing irons and low carbon steels are in this class.

Copper, brasses, bronzes—Copper forgings have extensive applications in the electrical field. The brass and bronze alloys have moderate corrosion resistance properties. Some of the bronzes have moderately high strength and good bearing properties.

Nickel, nickel-copper alloys—Pure nickel is forgeable. The alloy of nickel and copper known as monel metal offers a desirable combination of strength, toughness and corrosion resistance.

Light alloys (aluminum, magnesium)—The light alloys have about one-third the weight of steel, and some have approximately the strength of low carbon steel. Forgeable alloys are available in both the aluminum and magnesium groups.

Titanium—Titanium and its alloys have been forged for the production of aircraft components. Special dies are necessary and intricate forgings require more stages than steel.

Commercial forging practice. Impression die forgings are sold by the piece and not by the pound. It is understood without specific mention that the excess metal or flash of forgings shall be removed by trimming, and that forgings shall be free from injurious defects.

Quantity—The quantity specified permits standard practice limits on over-runs and under-runs.

Size—Forgings within commercial size limits will be furnished unless closer tolerances are specified.

Coining or sizing—Closer tolerances may be obtained by additional hot or cold sizing operations.

Surfacing conditions—Forgings are furnished in a cleaned condition obtained by tumbling, pickling or blast cleaning unless otherwise specified.

Special requirements—Any special requirement, such as heat treatment or special tests, should be clearly stated.

Preparation charges—The production of impression die forgings requires the preparation of special dies and tools which may be charged to the customer as a separate item called "preparation charges." The customer has the exclusive right to use such dies and tools, but because the full cost is generally not included in such a charge he does not have the right to remove them without additional payment. Any such dies and tools are maintained in the future without further charges to the customer.

Tolerances. Standard tolerances given on these pages are for forgings up to 100 lb.

Special tolerances may be specified when regular tolerances are not applicable. Regular tolerances, shown here, are classed as "Commercial Standard" and "Close Standard."

MISMATCHING TOLERANCES[a]

Weight of Part ↓	Commercial, in.	Close, in.
Net Weight up to—		
1 Lb.	0.015	0.010
7 Lb.	0.018	0.012
13 Lb.	0.021	0.014
19 Lb.	0.024	0.016
Each Additional 6 lb Add.	0.003	0.002
For Example:		
37 Lb.	0.033	0.022
55 Lb.	0.042	0.028

[a] Mismatching tolerances are independent of, and in addition to, any other tolerances. Mismatching is the displacement of a point—in that part of a forging formed by one die block of a pair—from its desired position when located from the part of the forging formed in the other die block of the pair. Mismatching does not include any displacement caused by variation in thickness of the forging, but is only the displacement in a plane parallel to the main or fundamental parting plane of the dies.

Metal Powder Parts

General

Metal powder parts are made by compacting loose metal powders in a die and subsequently sintering the compact to form a structural part. Additional operations may be used to obtain special results.

Materials. Materials combinations impossible by other processes are commonplace in metal powder parts. Among the materials used are: iron, steel, stainless steel, copper, brass, bronze, monel, nickel, tin, tungsten, zirconium, graphite, and various oxides and carbides. Powders of these materials are produced by a variety of methods, the most common being reduction of oxides or ores, electrolytic deposition, atomizing, mill grinding and thermal decomposition of carbonyls.

Advantages. Powder metallurgy permits the use of metallic combinations that would not be possible to melt, and permits close control over structure, which may be dense or porous as desired.

Limitations. Metal powder parts must be of relatively simple shape because: 1) dies must permit easy removal of parts, 2) most powders have poor flow qualities, and 3) it is difficult to transmit pressures through great depths of powder. Where other considerations make it practicable, more complex shapes can be produced by using costly, intricate dies and double-acting presses. Because powder metallurgy is not capable of holding extremely close dimensional tolerances, secondary sizing or coining operations are sometimes required. Size of metal powder parts is restricted both by available press sizes and by the difficulty of transmitting pressure through powder. Initial tool costs are high. Production volumes of less than 50,000 parts are normally not economical although there are cases where 10,000 parts or less have proved feasible.

Mixing. The powders are mixed with alloying additives and lubricants. In rare cases (e.g., preparation of prealloyed powders) thermal treatment may be required before compacting.

Compacting. Compacting (or pressing) to proper density and shape requires pressures of from 5 to 50 psi in mechanical or hydraulic presses. The dies are usually made of hardened tool steel or cemented carbides and must be lapped to a high polish.

Sintering. This operation is performed at a temperature which is usually 70 to 80% of the melting point of the major constituent. Sintering time ranges from ½ hr to several hours. Volatile materials are driven off and, if present in quantity, can result in porosity. The furnace atmosphere must be carefully controlled to prevent oxidation.

Infiltrating. In this additional step, sometimes desirable, a molten metal of lower melting point than the major constituent is forced into the part under pressure, penetrating and solidifying within the pores. Infiltration increases strength by 70 to 100%.

Other operations. Presintering may be used before parts are machined. Coining (or sizing) is often used to provide closer tolerances and increased strength; pressures used are equal to or greater than the initial pressure. Coining may be followed by another sintering operation. Other operations possible include machining and case or precipitation hardening. A common finishing process is the introduction of oil into the pores of bearings.

Properties of the Powders

The properties of metal powder parts are highly dependent on the qualities of the powders used. The most important of these are:

Purity. Clean particle surfaces insure good contact between particles (needed for optimum mechanical properties). The presence of foreign particles must to be held to a minimum, usually specified.

Apparent density. Apparent density (sometimes bulk density) is the weight of a unit volume of powder and is of particular importance in the pressing operation. The lower the value, the greater the volume of powder needed for a part of given size.

Compressibility. The ability of a metal powder to be pressed is important for both fabrication and end properties. Compressibility (ratio of volume of loose powder to volume of compact) is affected by physical characteristics of powder particles and distribution of particle size.

Particle size distribution. Also called sieve analysis, this property is usually expressed as the percentage by weight of powder that can be retained on each of a series of standard sieves of decreasing size. It affects press feed, dimensional changes during sintering, porosity of the compact, and final attainable density and strength.

Flow rate. The ease with which a metal powder can be fed into the die is determined by its flow rate. Low flow rates slow up automatic pressing operations and may require the use of vibrating equipment.

Sintering properties. Sintering is usually done in an inert, reducing or neutral atmosphere, or in a vacuum. The sintering temperature of metal powders is critical; therefore, for production purposes it is desirable to have a furnace with a reasonably wide temperature range.

Green strength. This is the powder's ability to be handled without breakage after compacting and before sintering.

Properties of the Parts

Mechanical and physical properties of sintered parts are closely related to the final density that can be achieved. In general, as density of a metal powder part increases, strength also increases, and at 100% density the properties theoretically will be at least equal to those of solid stock.

As yet, few standard tests for determining mechanical properties have been established, and in many cases conventional methods are not adequate. In addition, it is not feasible to give detailed information concerning strength properties because they depend on so many variables (e.g., type and size of powder, pressing pressure, sintering temperature, coining and other operations). The table included here is a rough guide to the strength ranges that can be expected with the most common metal powder formulations.

Production Factors

Metal powder parts may be classified in order of increasing difficulty of production according to each of three factors: design, tolerances and density.

Design classification. I—plain circular or profiled parts, II—plain circular or profiled parts with holes, III—parts with external flanges, IV—parts with internal flanges, V—parts requiring multiple punch motions.

Tolerance classification. a—wide, b—medium, c—narrow.

Density Classification. 1—low (below 6.3 gm per cu cm), 2—medium (from 6.3 to 7.1 gm per cu cm), 3—high (above 7.1 gm per cu cm).

Thus, difficulty in producing metal powder parts ranges from Ia1 to Vc3.

Design Factors

Wall thickness. A wall as thin as 0.030 in. is possible on small parts, but a general rule calls for a minimum thickness of 0.032 in. per in. of length of the section. Large variations in section thickness are undesirable.

Tolerances. There are two different classes of tolerances for metal powder parts: tolerances on dimensions which are tool dependent only, and tolerances that are dependent on both press and tool (generally only the overall dimension in the pressing direction). The accompanying table illustrates that the narrowest tolerances are obtainable only if the last processing step involves a sizing or coining operation, and in some cases a precipitation hardening treatment. These narrow tolerances compare with medium grinding or broaching tolerances. Tolerances for parts that are sintered but not sized compare with medium to wide tolerances for screw machine or milled parts.

Design Rules

1. Cylinders, squares and rectangles are the most favorable shapes. When a shape deviates from these, it is essential that it be uniform in the direction of pressing.
2. Contours must be in a plane at right angles to the direction of pressing.
3. Avoid feather or knife edges; narrow, deep splines; thin projections; and sharp corners.
4. Radii of at least 0.010 in. should be provided in corners, and edges should be given a 45-deg chamfer.
5. Length of part in pressing direction is normally limited to 3 to 6 times the cross sectional area.
6. Use inserts sparingly as they are difficult to mold in.
7. Shoulders in a solid top punch require 1 to 5 deg taper to assist removal.
8. To prevent trapping powder in an acute angle between punch and die, a small horizontal step is recommended.
9. Use flat punches for less breakdown time.
10. An acute angle for a lead-in can sometimes be produced by a coining operation.
11. Undercuts cannot be molded.
12. Parts with multiple steps should be designed with a minimum width of 0.035 in. for each step.
13. Complete spheres cannot be molded.
14. Avoid re-entrant angles.
15. If a projection is opposite the blind end, one or the other must be modified.
16. Grooves in top face of parts can be molded within following limits: 30% of total height for curved grooves, 20% for square. A 5-deg min taper is necessary on vertical sides.
17. Avoid flats on flanges requiring thin punches.
18. Avoid vertical radii on edges.
19. Joining metal powder parts offers special difficulties.
20. **Corrosion** protection requires special precautions.

TOLERANCES FOR METAL POWDER PARTS

Final Operation ↓	Tolerances, in. per in.[a]		
	Narrow	Medium	Wide
Coining[b]	0.0052, —	0.00208, 0.00132	—, 0.0052
Sintering	—, —	0.00208, 0.00326	0.0084, 0.0208
Case Hardening	—, —	0.00208, 0.0052	0.0208, 0.0208

[a] The first tolerance refers to dimensions which are tool-dependent only; the second to those which are both tool and press-dependent. A dash means the particular class of tolerance is not held.

[b] And possibly precipitation hardening.

PROPERTIES OF SOME COMMON TYPES OF METAL POWDER PARTS

Material[a]	Composition, %	Density, gm/cu cm	Ten Str, 1000 psi	Hardness (Rockwell)	Elong (1 in.), %	Compr Yld Str, 1000 psi[b]
Iron		6.5	22–26	F20–30	2–5	18–21
Iron		7.3	35–38	B15–25	20–28	29–34
Iron-Copper	Cu 1.5–2.5	7.0	35	B30–50	10	26
Iron-Copper-Carbon	Cu 1.5–2.5, C 0.25–0.60	7.0	42	B35–60	7	38
Iron-Copper-Carbon	Cu 1.5–2.5, C 0.6–1.0	7.0	50	B60–80	5	48
Iron-Carbon	C 0.25–0.60	6.5	27	B20–30	2	23
Iron-Carbon	C 0.6–1.0	7.0	48	B55–75	3	45
Iron-Carbon	C 0.6–1.0	6.5	35	B35–45	½	27
Infiltrated Iron	C 0.25	7.3	65	B55–65	1	70
Infiltrated Iron	C 0.6–1.0	7.3	100	B65–75	0.5	120
Stainless Steels	304 and 316	6.0–6.5	40–75	F64–85	12–25	—
Copper		8.3	26–27	H30–40	16–23	20–22
Brass	Cu 78.5, Pb 1.5	7.5–7.8	27–29	H71–78	13–24	14–18
Bronze	Sn 9.5–10.5	6.8–7.2	16–20	H65–90[c]	2–3	15-20
Nickel Silver		7.5–7.8	28–34	H78–81	10–15	19

[a] Annealed condition except bronze. [b] At 0.1% offset. [c] Depends largely on degree of cold working.

Screw Machine Parts

General

Advantages. Perhaps the greatest advantage of screw machine parts is the extreme speed at which they can be produced. Production rates can reach—and even exceed—4000 parts per hr. Extremely close tolerances can be held. Finishes are usually superior to those attained by other methods. Since bar or tube stock is used as the raw material, mechanical properties are usually high.

Limitations. Scrap losses are usually high because the over-all size of the bar must be as great, or greater than, the largest diameter of the part.

Materials. Nearly any machinable metal can be used for screw machine parts if it is available in bar or tubular form. For best results, though, the material should be free machining and should not be too soft, too hard or too stringy (since such materials make it difficult to maintain production speeds and also cause inferior surface finish). The majority of screw machine parts are made from free-machining steels, free-cutting brasses, and aluminum and magnesium alloys.

Design Rules

Restrictions are imposed by the requirement that all parts must have surfaces of rotation that are concentric with the axis of the stock being machined. However, interior and exterior undercuts are possible, and nearly any type of thread can be produced.

Square corners are not desirable. Chamfers are preferred, but if rounded edges are desired, liberal radii should be provided. Dimensions can be held to ±0.001 to ±0.003 in. without difficulty and, when necessary, they can be as close as 0.0005 in.

Maximum size is limited, but screw machine parts can be extremely small. The range of sizes normally encountered is ¼ in. up to 8 in. in dia, and a fraction of an inch up to 6-8 in. in length.

MACHINABILITY RATINGS (Based on AISI B1112 = 100)

Aluminum Alloys (wrought)	
3003	Soft
2011	Excellent
2014	Average
2017	Average
2018	Average
2024	Average
6151	Soft
5052	Soft
5056	Average
6061	Soft
6063	Soft
7075	Average
Aluminum Alloys (cast)	
43	Soft
85	Soft
108	Soft
113	Average
122	Excellent
138	Average
142	Average
195	Average
212	Average
214	Average
220	Excellent
319	Soft
355	Soft
380	Soft
750	Excellent
Coppers	
Copper, 99.9%	40
Electrolytic Tough Pitch	40-50
Leaded Copper	160
Oxygen-Free Copper	40
Phosphorized Copper	40
Selenium Copper	180
Tellurium Phosphorized Coppers	180
Copper Alloys	
Aluminum Bronze (alpha), 92-95%	60-80
Copper Alloys (cont'd)	
Aluminum Bronze (duplex)	60-100
Architectural Bronze, 58%	180
Beryllium Copper, 97%	40
Cartridge Brass, 70%	60
Commercial Bronze, 90%	40
Forging Brass, 60%	160
Free Cutting Brass, 61.5%	200
Gilding Bronze, 95%	40
Gun Metal (cast), 95.8%	60
High Leaded Brass, 62%	180
Leaded Commercial Bronze, 89%	180
Leaded Naval Brass, 60%	140
Leaded Nickel Silver, 46%	160
Leaded Phosphor Bronze (B_1)	100
Leaded Phosphor Bronze (B_2), 94%	200
Leaded Silicon Bronze, 95.6%	120
Low Brass, 80%	60
Low Leaded Brass, 64%	140
Manganese Bronze, 59%	60
Muntz Metal, 60%	80
Naval Brass, 60%	60
Nickel Silvers	40
Phosphor Bronze, 92% (Grades A, C, D, E)	40
Red Brass, 85%	60
Silicon Bronze, 95.8%	60
Irons	
Cast Iron	
Soft	80
Medium	65
Hard	50
Ingot Iron	50
Irons (cont'd)	
Malleable Iron	
Standard	120
Pearlitic	80
Wrought Iron	50
Magnesium Alloys	
(wrought)	500-2000
Nickel and Its Alloys	
Nickel	20
Nickel Alloys (rolled)	40-55
Monel (cast)	35
Monel (rolled)	40-55
Monel, K	40
Screw Machine Steels	
SAE 1120 (leaded)	140
SAE X1112	140
SAE 1112	100
SAE X1314	90-95
SAE X1315	90-95
SAE 1120	70-75
SAE X1335	70-75
SAE X1350	70-75
Carburizing Steels	
SAE X1020	50-65
SAE 1025	50-65
SAE 1020	50-65
SAE 1015	50-65
SAE 6120 (annealed)	45-50
SAE 6115	45-50
SAE 3115	45-50
SAE 4615 (annealed)	45-50
SAE 2315 (annealed)	45-50
SAE 3215	45-50
Heat Treating Steels	
SAE 1035	55-60
SAE 1040	55-60
Heat Treating Steels (cont'd)	
SAE 1045 (annealed)	55-60
SAE 4130 (annealed)	40-50
SAE 4140 (annealed)	40-50
SAE 3140 (annealed)	40-50
SAE 6135 (annealed)	40-50
SAE 6140 (annealed)	40-50
SAE 6150 (annealed)	40-50
SAE 1335 (annealed)	40-50
SAE 1350 (annealed)	30-40
SAE 2330 (annealed)	30-40
SAE 2345 (annealed)	30-40
SAE 3140	30-40
SAE 2345	30-40
SAE 52100 (annealed)	30-40
Stainless Steels	
Type 405	55
Type 406	50
Type 430	50
Type 442	60
Type 443	60
Type 446	65
Type 430-F	90
Type 403	50
Type 410	50
Type 414	60
Type 416	85
Type 420	50
Type 420-F	70
Type 431	54
Type 440	40
Type 501	70
Type 502	70
Type 302	35
Type 303	60
Type 304	45
Type 309	48
Type 316	46
Type 317	45
Type 321	50
Type 347	48
Zinc	200

Spinnings

ADAPTABILITY OF METALS TO SPINNING

Material ↓	Shallow Spinning	Deep Spinning
Group 1—Aluminum and Its Alloys		
1100-O	1.00	1.00
3003-O	1.00	0.99
2024-O	0.65	0.45
5052-O	0.80	0.55
6061-O	0.90	0.80
Group 2—Copper and Its Alloys		
Copper (cold rolled, annealed)	1.00	1.00
Copper (hot rolled)	0.99	0.88
Yellow Brass	0.99	0.92
Cartridge Brass, 70%	0.99	0.92
Low Brass, 80%	0.96	0.89
Red Brass, 85%	0.90	0.83
Commercial Bronze, 90%	0.88	0.80
Gilding, 95%	0.85	0.75
Admiralty	0.82	0.70
Naval Brass	0.75	0.45
Muntz Metal	0.55	0.30
Phosphor Bronze A	0.85	0.40
Phosphor Bronze C	0.85	0.45
Cupro Nickel, 30%	0.95	0.65
Nickel Silver A	0.95	0.65
Silicon Bronze	0.94	0.60
Group 3—Carbon and Low Alloy Steels		
Cold Rolled (deep drawing quality)	1.00	1.00
Vitreous Enameling (deep drawing and spinning quality)	1.00	0.95
Cold Rolled (standard)	1.00	0.92
Hot Rolled (pickled and oiled)	1.00	0.92
Hot Rolled (low carbon)	0.90	0.55
Hot Rolled (copper-bearing)	0.88	0.51
Lead Coated (long terne)	1.00	[a]
Galvannealed	1.00	[a]
Galvanized	0.90	[a]
High Strength	0.45	0.15
Carbon (0.40% and above)	0.25	0.10
Group 4—Stainless Steels		
Type 302	0.98	0.60
Type 304	0.98	0.90
Type 305 (free-spinning)	1.00	1.00
Type 309S	0.80	0.45
Type 316	0.90	0.60
Type 321	0.85	0.50
Type 347	0.90	0.50
Type 430	0.90	0.50
Group 5—Nickel and Its Alloys		
Monel (spinning quality)	1.00	0.90
Monel (special cold rolled, soft temper)	1.00	0.85
Inconel	0.90	0.70
Nickel (low carbon)	1.00	1.00
Nickel	1.00	0.92
Multimet N-155	0.90	0.50
Hastelloy A	0.75	0.35
Hastelloy B	0.70	0.30
Hastelloy C	0.50	0.10
Group 6—Miscellaneous Metals		
Lead	0.96	0.90
Pewter	1.00	0.99
Zinc	1.00	1.00
Tantalum	0.86	0.45
Magnesium	0.80	0.45
Molybdenum	0.55	0.15

[a] Impractical—coating flakes off.

Cold spinning is done by applying localized pressure to a rotating disk of sheet metal to draw it over a male form. The form is usually of hardwood, sometimes metal, and must be polished smooth or surface roughness will show in the finished part.

Advantages. Simple, economical operation for small-lot production, particularly for shapes that can be withdrawn directly from a one-piece chuck. Multisection or offset chucks can be used.

Limitations. Considerable skill is required by the operator because the spinning tool (a rounded-end wood or metal tool, or roller) is held and manipulated manually. Usually there is some thinning of the material.

Design Factors. The tolerances held by spinning operations are often closer than for drawn parts. It is also possible to neck over collapsible forms certain parts that could not be produced by drawing or shaping in positive dies.

Materials. Most metals, with the exception of magnesium and molybdenum, can be cold spun. Metals such as gold, silver, platinum, Kovar, Invar and Illium can be spun but require special handling.

Adaptability. Adaptability of metals to the spinning process is rated in the chart given above. The unit 1.00 is assigned to the type of material in each group that lends itself most readily to cold spinning. The lower the index, the higher the cost. These figures will vary slightly with contour, gage and size.

This analysis applies to manual metal spinning by the cold method. Where quantities warrant special automatic spinning setups, or where existing automatic setups can be used, difficult-to-form metals can be deep spun readily. The deep spinning ratings in the table do not apply under these conditions.

Mechanical Tubing

General

Mechanical tubing is manuactured specifically for further processing into fabricated tubular products. It is of uniform high quality and produced to close tolerances. In addition, it usually has good machining qualities and relatively high finish, and is available in a wide range of materials, analyses, shapes and sizes.

The word "tubing" is used to describe several different products, including pipe and casing; however, it refers more specifically to seamless or welded tubular forms which are manufactured to closer size tolerances than pipe. Another distinction is that practically all pipe is round in section.

Advantages. For some parts, such as relatively long, thin-walled cylindrical objects, tubing is the only answer. On the other hand, there are many uses where tubing competes with bar, punchings, machined parts, weldments and castings. In such cases tubing may offer savings in weight, inherent structural strength, and reduction in fabricating time and costs, particularly in machining operations.

The applications of tubing are extended by its ability to be worked and fabricated into parts by many methods (e.g., bending, swaging, spinning, flaring, machining, joining). Because of this adaptability, it actually serves as a semifinished form which can be further shaped into the finished product. In many applications the forming is of such a nature that the tubing practically loses its identity as such.

Materials. Carbon, alloy and stainless steels; copper and copper alloys; nickel and nickel alloys; aluminum and its alloys; magnesium alloys; and titanium. In addition, specialty tubing is made from a number of other, less common materials.

Types. Tubing is produced either seamless or welded. Seamless has no longitudinal seam (however, seamless tubing is often joined end to end by a circumferential weld). Welded tubing is manufactured from flat stock and has a longitudinal seam. Some of the materials mentioned above can be produced only in seamless or only in welded tubing.

Comparisons. Seamless and welded tubing are alike in many of their characteristics, but differ in others. Welded tubing is made with relatively thin walls. Seamless is produced in a larger range of sizes and wall thicknesses, including heavy walls. Closer wall thickness tolerances can be maintained with welded tubing than with seamless.

In mechanical properties, as-welded tube is about equal to the flat stock from which it is formed. Its properties are generally lower than those of cold drawn seamless tubing because of the improvement in properties resulting from cold work. However, drawn welded tubing compares with seamless in its properties. Both welded and seamless tube are closely comparable in their forming characteristics.

TOLERANCES FOR TITANIUM TUBING[a]

Diameter, in.[b] ↓	Cold Drawn[c]		Extruded	
	O. D. Tol, in.	Wall Thk Tol, %	O. D. Tol, in.	Wall Thk Tol, %
Up to 1½ . . .	0.010[d]	10	—	—
1½ to 3½ . . .	0.010	10	—	—
3½ to 5½ . . .	0.015	10	0.031	14[e]
5½ to 8	0.030	10	0.047	12.5
8 to 10¾	—	—	0.063	12.5

[a] Round tubing. All values ±.
[b] Range is not inclusive of higher value.
[c] Welded or seamless; also welded with weld area cold worked.
[d] Some producers state 0.005 in. here.
[e] 12.5% if wall thickness is over 0.203 in.

Temper and finish. Tubing of most materials is furnished in a number of different conditions or tempers to meet specific forming or service requirements. It is also normally available in at least one or two standard finishes. The finishes depend upon the material and methods of manufacture. Where required, any one of a variety of special finishes can be had on order. For example, tubing can be obtained with a special inside surface, a special outside surface, or both. For applications such as plated parts, or parts requiring exceptionally smooth, uniform surfaces, the tubing can be furnished ground and polished.

Design Factors

Shape. By proper design of the part and careful selection of the shape and size of the tubing, machining and other shaping operations can be cut to a minimum. The most common shape is the round section. Square and rectangular sections are often produced as standard shapes in a wide range of sizes. The following are some of the special shapes that can be produced on order: embossed; fluted outside, plain inside; fluted; hexagon; lip; octagon; pinion (longitudinal serrations on outside); polygonal outside, plain inside; reeded; roped; rope-fluted; rope-reeded; round outside, polygonal inside; and twisted.

Cost. Tubing may cost more than bar stock, but savings in processing often offset additional materials cost. Thus, drilling operations can be eliminated, and drills replaced by simple, less expensive boring tools. Boring can be done faster than drilling; chucking pressures are reduced. There is also less tool wear and fewer tool changes.

Tolerances. Round tubing has three cross-sectional dimensions which must be considered in ordering and fabricating. They are outside diameter (o.d.),

DIAMETER TOLERANCES FOR CARBON AND ALLOY STEEL WELDED TUBING[a]

Diameter, in.[b] ↓	Wall Thickness, BWG	Cold Rolled Carbon Steel				Hot Rolled Carbon Steel		
		Standard Tolerance[c]		Close Tolerance[d]		Standard Tolerance[c]		Close Tolerance[e]
		O.D., in.	I.D., in.	O.D., in.	I.D., in.	O.D., in.	I.D., in.	O.D., in.
¼ to ⅜	22 to 14......	0.0025	0.009	—	—	—	—	—
	20 to 14......	—	—	0.002	0.005	—	—	—
	16 to 14......	—	—	—	—	—	—	0.002
⅜ to ⅝	22 to 16......	0.003	0.005	—	—	—	—	—
	20 to 12......	—	—	0.0025	0.0025	—	—	—
	16 to 12......	—	—	—	—	—	—	0.0025
	14 to 12......	0.003	0.009	—	—	—	—	—
⅝ to 1⅛	22 to 14......	0.0035	0.005	—	—	—	—	—
	20 to 11......	—	—	0.0025	0.0025	—	—	—
	16 to 11......	—	—	—	—	0.0035[f]	0.012[f]	0.0025
	13 to 11......	0.0035	0.008	—	—	—	—	—
1⅛ to 2	22 to 14......	0.005	0.006	—	—	—	—	—
	20 to 9......	—	—	0.003	0.003	—	—	—
	16 to 14......	—	—	—	—	0.005	0.010	—
	16 to 9......	—	—	—	—	—	—	0.003
	13 to 9......	0.005	0.008	—	—	—	—	—
	13 to 7......	—	—	—	—	0.005	0.015	—
2 to 2½	20 to 14......	0.006	0.007	—	—	—	—	—
	20 to 9......	—	—	0.004	0.004	—	—	—
	16 to 14......	—	—	—	—	0.006	0.012	—
	16 to 9......	—	—	—	—	—	—	0.004
	13 to 9......	0.006	0.009	—	—	—	—	—
	13 to 6......	—	—	—	—	0.006	0.016	—
2½ to 3	20 to 18......	0.008	0.012	—	—	—	—	—
	18 to 9......	—	—	0.005	0.005	—	—	—
	16 to 14......	—	—	—	—	0.008	0.012	—
	16 to 9......	0.008	0.010	—	—	—	—	0.005
	13 to 4......	—	—	—	—	0.008	0.016	—
3 to 3½	20 to 9......	0.009	0.012	—	—	—	—	—
	16 to 14......	—	—	—	—	0.009	0.015	—
	13 to 4......	—	—	—	—	0.009	0.020	—
3 to 4	18 to 8......	—	—	0.006	0.006	—	—	—
	16 to 8......	—	—	—	—	—	—	0.006
3½ to 4	20 to 8......	0.010	0.015	—	—	—	—	—
	16 to 14......	—	—	—	—	0.010	0.017	—
	13 to 4......	—	—	—	—	0.010	0.021	—
4 to 5	16 to 14......	0.020	0.020	—	—	0.020	0.022	—
	13 to 8......	0.015	0.018	—	—	—	—	—
	13 to 4......	—	—	—	—	0.015	0.026	—

[a] Round tubing. All values are ±.
[b] Range is not inclusive of lower value.
[c] Flash controlled to 0.005-in. max.
[d] Mandrel flash removed.
[e] Without mandrel. Same values hold for cold rolled close tolerance without mandrel.
[f] Diameter range for this tolerance is actually ¾ to 1⅛ in.

inside diameter (i.d.), and wall thickness or gage. In seamless and drawn welded tubing each of the dimensions may vary independently; therefore it is important to have a knowledge of the tolerances to which the tubing is manufactured. This information can be found in the accompanying tables.

continued on next page

Mechanical Tubing

WALL THICKNESS TOLERANCES FOR CARBON AND ALLOY STEEL WELDED TUBING[a]

Wall Thickness		Wall Thickness Tolerance, in.[b]	
BWG	In.	Cold Rolled	Hot Rolled
22	0.028	+0.000, −0.003	—
20	0.035	+0.000, −0.004	—
18	0.049	+0.000, −0.004 to −0.005	—
16	0.065	+0.000 to +0.002, −0.004 to −0.007	+0.002, −0.006 to −0.010
14	0.083	+0.000 to +0.002, −0.004 to −0.007	+0.002 to +0.003, −0.006 to −0.012
13	0.095	+0.000 to +0.002, −0.004 to −0.007	+0.002 to +0.003, −0.006 to −0.012
12	0.109	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.006 to −0.012
11	0.120	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.008 to −0.012
10	0.134	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.008 to −0.012
9	0.148	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.008 to −0.012
8	0.165	+0.000 to +0.003, −0.007 to −0.010	+0.002 to +0.005, −0.008 to −0.012
7	0.180	—	+0.002 to +0.005, −0.008 to −0.012
6	0.203	—	+0.002 to +0.005, −0.010 to −0.013
5	0.220	—	+0.002 to +0.005, −0.010 to −0.013
4	0.238	—	+0.002 to +0.006, −0.010 to −0.018
—	0.250	—	+0.006 to −0.018

[a] Round tubing.
[b] Ranges are given because tolerance varies with o.d.

TOLERANCES FOR CARBON AND ALLOY STEEL SEAMLESS TUBING[a, b]

Diameter, in.[c] ↓	Finish Annealed		Soft Annealed	
	O.D. Tol, in.	I.D. Tol, in.	O.D. Tol, in.	I.D. Tol, in.
3/16 to 1/2	±0.004[e]	—	+0.006, −0.002	—
1/2 to 1 1/2	+0.005[d, e, f]	−0.005[d, e, f]	+0.008,[d, e, f] −0.002	+0.002,[d, e, f] −0.008
1 1/2 to 3 1/2	+0.010[d, e, f]	−0.010[d, e, f]	+0.015,[d, e, f] −0.005	+0.005,[d, e, f] −0.015
3 to 5 1/2	+0.015[d, f]	+0.005,[d, f] −0.015	+0.023,[d, f] −0.007	+0.015,[d, f] −0.025
5 1/2 to 8	±0.030[f, g] ±0.020[h] +0.030[d]	±0.035[f, g] ±0.025[h] +0.015,[d] −0.030	±0.060[f, g] ±0.040[h] +0.045,[d, i] −0.015	±0.070[f, g] ±0.050[h] +0.037,[d, i] −0.053
8 to 10 3/4	±0.045[f, g] ±0.035[h] +0.045[d, i]	±0.050[f, g] ±0.040[h] +0.015,[d, i] −0.040	— — —	— — —

[a] Applies to round cold finished tubing. Wall thickness tolerance is 10% except 15% for 3/16 to 1/2 in. dia.
[b] O.d. tolerances for hot finished tubing: ±0.023 for dia up to 3 1/2 in.; ±0.031 for 3 to 5 1/2 in.; ±0.047 for 5 1/2 to 10 3/4 in. Wall thickness tolerances for hot finished tubing: ±16.5% for wall thickness less than 0.109 in.; ±15% for 0.110 to 0.172 in.; ±14% for 0.173 to 0.203 in.; 12.5% for thicker walls.
[c] Below 8 in., ranges are not inclusive of higher figure.
[d] For tubes which cannot be successfully drawn over a mandrel [often true of those with: 1) i.d. <50% of o.d., 2) wall >25% of o.d., 3) wall >1 1/4 in. thk, 4) weight >90 lb per ft], i.d. tolerance is ±10% of the wall thickness and wall thickness tolerance is 12%.
[e] For certain other tubes which are not commonly drawn over a mandrel (specifically, those with i.d. < 1/2 in., or with i.d. < 5/8 in. when wall thickness >20% of o.d.), the wall thickness tolerance is 15% and the i.d. is governed by the standard tolerances for o.d. and wall thickness.
[f] Tubes with wall <3% of o.d. cannot be straightened properly without distortion and require an additional ovality tolerance of ±1/2% for the o.d. and i.d.
[g] When wall <5% of o.d. [h] When 5% of o.d. < wall < 7.5% of o.d. When wall >7.5% of o.d.

TOLERANCES FOR STAINLESS STEEL TUBING[a]

Diameter, in.[b]	Diameter Tolerances[c]			Wall Thk, in.	Wall Thk Tol for Welded Tubing, in.[d, e]
	Seamless O.D. Tol, in.	Welded			
		O.D. Tol, in.	I.D. Tol, in.		
Up to 3/32	0.005	0.001	0.001	0.025	0.002–0.003
3/32 to 3/16	0.005	0.0015	0.0015	0.032	0.003–0.004
3/16 to 1/2	0.005	0.003	0.005	0.035	0.003–0.005
1/2 to 1	0.005	0.004	0.006	0.042	0.003–0.005
1 to 1 1/2	0.005	0.005	0.007	0.049	0.003–0.005
1 1/2 to 2	0.010	0.006	0.008	0.058	0.004–0.006
2 to 2 1/2	0.010	0.007	0.010	0.065	0.005–0.006
2 1/2 to 3 1/2	0.010	0.010	0.014	0.072	0.005–0.007
3 1/2 to 5	0.015	0.015	0.020	0.083	0.005–0.007
3 1/2 to 5 1/2	0.015	—	—	0.095	0.005–0.007
5 1/2 to 8	0.030	—	—	0.109	0.005–0.007
8 to 8 5/8	0.045	—	—	0.120	0.005–0.007
				0.134 and over	0.007–0.008

[a] Round tubing; annealed or as cold finished. All values are ±.
[b] Ranges are not inclusive of upper values.
[c] Tolerances are general and subject to limitations by D/t ratio. Ovality tolerance is generally double the o.d. tolerance.
[d] Tolerance for seamless is ±10%; 15% when o.d. < 1/2 in.
[e] Ranges are given because tolerance varies with o.d.

TOLERANCES FOR NICKEL AND NICKEL ALLOY SEAMLESS TUBING[a]

Dia, in.	Dia Tol, in.[b,c]	Wall Thk Tol, %[b]
Monel, A Nickel, Low Carbon Nickel		
Up to ⅝	+0.005	12.5
⅝ to 1½	0.005	10
1½ to 4½	0.010	10
4½ to 6	0.015	12.5
6 to 7½	0.020	12.5
7½ to 8⅝	0.025	12.5
Inconel, Inconel X, K Monel, Incoloy		
Up to ⅝	0.005	15
⅝ to 1½	0.0075	10
1½ to 3½	0.010	10
3½ to 4½	0.015	10
4½ to 6	0.020	12.5
6 to 6⅝	0.025	12.5

[a] Round cold drawn. All tolerances ± except where otherwise indicated. Tolerances given here are applicable only to two dimensions at a time. Diameter ranges are not inclusive of lower values.

[b] The following applies only to tubes which cannot be successfully drawn over a mandrel: 1) If i.d. < 50% of o.d., the i.d. tolerance is ±10% of the wall thickness and the wall thickness tolerance is 12½% for alloys in top part of table, 15% for others; 2) if i.d. < ½ in., the i.d. will be governed by standard tolerances for o.d. and wall thickness.

[c] Tubes with wall < 3% of o.d. cannot be straightened properly without distortion and require an additional ovality tolerance of ±½% for the o.d. and i d. Tubes furnished in soft annealed temper may possess ovality because of warpage during annealing or straightening and will not have tolerances as close as table indicates.

TOLERANCES FOR SMALL DIAMETER TUBING[a]

Dia, in.[b]	O.D. Tol, in.	I.D. Tol, in.
Up to 3/32	+0.002	−0.002
3/32 to 3/16	+0.003	−0.003
3/16 to ½	+0.004	−0.004
½ to 1½	+0.005	−0.005

[a] Wall thickness tolerance is ±10%. These tolerances are general; suppliers specializing in particular materials or sizes often hold closer tolerances for standard tubing.

[b] Range is not inclusive of higher value.

TOLERANCES FOR COPPER AND COPPER ALLOY SEAMLESS TUBE[a]

Dia, in.[d] ↓	Mean Diameter Tolerances, in.[b]		Wall Thickness, in.[e] ↓	Wall Thickness Tolerances, in.[c]	
	Nonrefractory	Refractory		Nonrefractory	Refractory
Up to ⅛	0.002	0.0025[f]	Up to 0.018	0.001 –0.002	0.0015–0.0025
⅛ to ⅝	0.002	0.0025	0.018 to 0.025	0.002 –0.003	0.0025–0.004
⅝ to 1	0.0025	0.003	0.025 to 0.035	0.0025–0.004	0.003 –0.005
1 to 2	0.003	0.004	0.035 to 0.058	0.003 –0.007	0.004 –0.009
2 to 3	0.004	0.005	0.058 to 0.083	0.0035–0.010	0.0045–0.013
3 to 4	0.005	0.006	0.083 to 0.120	0.004 –0.011	0.005 –0.014
4 to 5	0.006	0.008	0.120 to 0.165	0.005 –0.012	0.007 –0.015
5 to 6	0.007	0.009	0.165 to 0.220	0.007 –0.014	0.009 –0.018
6 to 8	0.008	0.010	0.220 to 0.284	0.009 –0.016	0.012 –0.020
8 to 10	0.010	0.013	0.284 to 0.380	0.011 –0.018	0.015 –0.023
			0.380 and over	5–6%	6–8%

[a] Round tubing. All values are ±.

[b] Tolerances apply to i.d. or o.d. except where otherwise indicated.

[c] Maximum deviation at any point; range indicates variation with o.d.

[d] Ranges are not inclusive of lower values.

[e] Ranges are not inclusive of upper values

[f] O.d. only; value for i.d. is 0.003 in.

TOLERANCES FOR EXTRUDED AND DRAWN ALUMINUM TUBING[a]

Diameter, in.[b] ↓	Diameter Tol, in.		Wall Thk, in. ↓	Wall Thk Tol, in.[c]	
	Drawn	Extruded		Drawn	Extruded
Up to ½	0.003	—	Up to 0.047	—	0.006
½ to 1	0.004	0.010	0.010 to 0.035	0.002	—
1 to 2	0.005	0.012	0.036 to 0.049	0.003	—
2 to 3	0.006	0.015	0.047 to 0.061	—	0.007–0.010
3 to 4	0.008	0.015	0.062 to 0.077	—	0.008–0.012
4 to 5	0.008	0.025	0.050 to 0.083	0.004	—
5 to 6	0.010	0.025	0.078 to 0.124	—	0.009–0.015
6 to 8	0.015	0.035	0.084 to 0.120	0.005	—
8 to 10	0.020	0.045	0.121 to 0.203	0.006	—
10 to 12	0.025	0.055	0.125 to 0.249	—	0.009–0.020
12 to 12.875	—	0.065	0.204 to 0.300	0.008	—
			0.250 to 0.374	—	0.011–0.025
			0.301 to 0.375	0.015	—
			0.375 to 0.499	—	0.015–0.035
			0.376 to 0.500	0.020	—
			0.500 to 2.000	—	0.020–0.075

[a] Round tubing. All values are ±.

[b] Range is inclusive of upper value for drawn tubing, lower for extruded.

[c] Allowable deviation of mean from specified wall thickness.

TOLERANCES FOR EXTRUDED MAGNESIUM TUBING[a]

Dia, in.[b]	Mean Dia Tol, in.	Wall Thickness, in.[b] ↓	Mean Wall Thk Tolerance, in.		
			O.D. to 2.99	O.D. 3.00–4.99	O.D. >5.00
Up to ½	0.008	Up to 0.062	0.007	0.008	0.010
½ to 1	0.010	0.063 to 0.124	0.008	0.010	0.015
1 to 2	0.012	0.125 to 0.249	0.009	0.013	0.020
2 to 4	0.015	0.250 to 0.374	0.011	0.016	0.025
4 to 6	0.025	0.375 to 0.499	0.015	0.021	0.035
6 to 8	0.035	0.500 to 0.749	0.020	0.028	0.045
8 to 10	0.045	0.750 to 0.999	—	0.035	0.055
10 to 12	0.055	1.000 to 1.499	—	0.045	0.065

[a] Round. All values are ±.

[b] Ranges are not inclusive of higher values.

Wire Parts, Forms and Assemblies

Advantages. Wire forms, ranging from simple bent or ended wire to welded wire assemblies, are used in original design as well as to replace stampings, castings and forgings. In addition to the extreme design adaptability, wire forms offer economy, resiliency, lightness and decoration.

Materials. Although basic steel wire is used for the majority of wire forms, any material which can be drawn into wire may be used. Special types of steel wire include: galvanized (rust protection), Bethanized (rust and corrosion protection), coppered or tinned (attractive finish at low cost), spring wire (added stiffness and tensile strength), stainless steel (electropolished), and Copperweld, Nickelply and Copperply for special applications. Standard nonferrous metals include: monel, copper, bronze, brass and nickel silver. Special metals used are: aluminum, tungsten and molybdenum.

Sizes. Wire diameters from 0.035 in. (20 gage) to 0.375 in. (⅜ in.) are usually suitable for most wire form designs. Sizes as large as 0.5 in. or as small as 0.0015 in. are sometimes required. Etched wire is produced in sizes down to 0.00012 in.

Finishes. Wire products may be finished by electroplating, enameling or lacquering. The most popular plated finishes are: nickel, chromium, brass, cadmium and zinc. Special finishes include: anodized aluminum, plastics coating, and a black oxidized finish applied over zinc plate.

Parts and Forms. In addition to the parts and forms discussed below, drawings on this page illustrate standard wire end treatments.

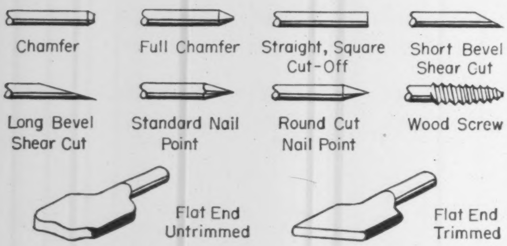
Eyes and ears—Eyes are formed in plain or teardrop shapes by plain or centered bends. Ears may be formed on one or both sides.

Upset pins—Standard pins are produced from wire of 0.010 to 0.125 in. dia, of any workable alloy and in various head shapes. If both a flange and head, or two or more flanges, are required, at least 0.070 in. spacing between adjacent faces is desirable.

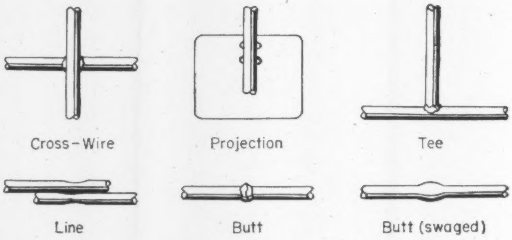
Wire threadings—Threads can be rolled or cut. Rolled thread has these advantages: less expensive; faster forming; no special fixtures; smaller dia wire required; chamfered end not necessary for easy starting. Cut thread has these advantages: stock size larger (or equal to) o.d. of thread; thread length not limited; can have chamfered end.

Formed rings—Rings may be formed on a wire ring coiler or a four-slide machine. Those formed on the slide machine do not butt perfectly; they are made from wire of 1/16 to 5/16-in. dia and in ring diameters of 1/2 to 2-in. i.d. Both flat and offset rings may be formed on the wire coiler. Wire diameter ranges from 1/16 to 5/16 in. and ring diameter from 5/8 to 3-in. o.d. Spiral rings are generally offset about one wire thickness.

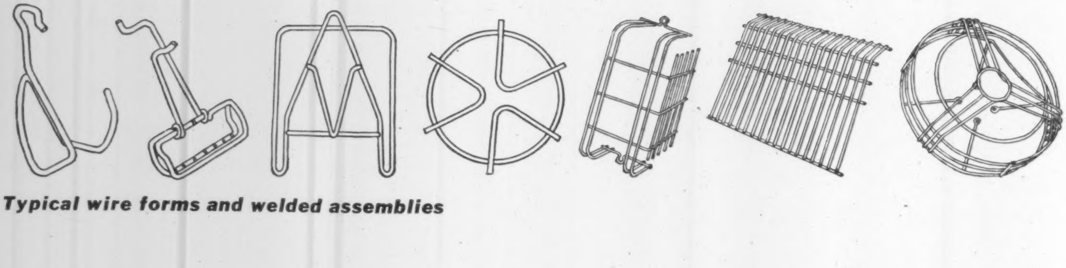
Welded wire assemblies. For attaching wire together, or wire to strip, the most efficient operation is resistance spot welding. It is preferable that welds occur where two wires cross each other at right angles.



Wire end treatments



Welded wire joints



Typical wire forms and welded assemblies

Plastics Parts

The form in which plastics materials should be specified is largely determined by the nature of the material. Plastics resins are either thermoplastic or thermosetting in nature. Thermoplastic resins soften and flow when heated and harden when cooled. For moldings, the polymer is usually supplied in granular form. After being heated to the fluid state it is charged to the mold or die, where it cools and hardens.

Thermosetting plastics do not soften when heated, but gradually lose properties as temperature increases, until they char and disintegrate. For moldings, thermosetting resins are usually supplied in a partially polymerized granular form, usually with some type of fibrous reinforcement. They flow to a limited degree on initial heating, but as heating continues they polymerize completely and cure to a hard infusible state.

Molded Parts

Injection molded parts. The injection molding process for plastics is similar in nature to the die casting process for metals. A thermoplastic molding compound is heated to plasticity in a cylinder at a controlled temperature and forced under a pressure of 10,000 to 50,000 psi through sprue, runners and gates into a cool single or multiple cavity mold. The resin solidifies rapidly, the mold is opened, and the part or parts ejected.

The primary advantage of the process, as is the case with die castings, is the relatively low cost per part. Multiple cavity molds can often be used. The cycle is rapid, since parts can be removed from the mold as soon as they solidify sufficiently.

In some cases modifications of the injection molding process can be used to mold small parts of thermosetting resins. These processes are called jet, flow or offset injection molding. They make use of the fluid state of thermosetting molding materials before complete polymerization. The process is suitable only for relatively small parts, and is one that requires careful control of processing variables, such as temperature.

Compression molded parts. Compression molding is primarily used to mold thermosetting plastics, though in some instances it can be used economically to mold thermoplastics, e. g., vinyl phonograph records. Thermoplastic materials cannot usually be preformed, but are charged as powder or granules.

In compression molding, a partially polymerized thermosetting resin, usually in the form of a preform made from powder or granules, is placed in the heated mold cavity. The mold is closed, heat and pressure are applied, and the material flows and fills the mold cavity. The heat then fully polymerizes the material before the mold is opened and the part removed.

In the case of thermoplastic materials, heating softens the polymer, which flows and fills the mold. Then the mold is cooled and the part solidifies.

Less material is required for compression molding than for injection or transfer molding, since the material is placed directly in the mold, and no sprues, runners or gates are required. With thermosetting resins, the cycle is longer than in injection molding, since the part must be cured in the mold.

Cold molded parts. Cold molding is similar to compression molding in that it makes use of a split, or open, mold in which the material is charged. It differs from compression molding in that it uses no heat—only pressure on the order of 2000 to 12,000 psi. After the part is removed from the mold it is placed in an oven to cure to its final state.

Materials used for cold molding are classified as nonrefractory (organic) and refractory (inorganic). Organic types consist of binders — such as asphalts, oil derivatives and residues, and gum or resin solutions — and fillers, such as asbestos fibers and silica and magnesia compounds. Inorganic types consist of binders — such as cement, lime or silica — and fillers, such as asbestos.

Cold molded parts are primarily used for electrical components. The materials have excellent electrical insulating properties, as well as resistance to moisture and heat.

Transfer molded parts. Transfer molding of thermosetting materials is roughly analogous to injection molding of thermoplastics. The thermosetting molding compound is heated to plasticity in a transfer chamber, and is then fed to the mold cavity (or cavities) through sprue, runners and gates. After the mold is filled, heat is maintained for a predetermined period of time to fully polymerize and cure the part.

In comparison with compression molding, transfer molding is particularly advantageous where thin sections or delicate inserts are used. Since the design of runners and gates permits some control over where the material is to be fed to the mold, flow of the material can be more closely controlled than in compression molding. Also, closer tolerances can usually be held on transfer molded parts. On the other hand, transfer molds are usually more elaborate than compression molds, and there is a loss of material in the cull and sprue. Size of transfer molded parts is somewhat limited.

Design factors. Though it is difficult to generalize about design factors for injection, compression and transfer moldings, the following factors should be considered:

Shrinkage—Allowance must be made for shrinkage of the molding compound in design of the part. In addition to affecting dimensional accuracy of the part, shrinkage can introduce internal stress which may make the part unserviceable. Shrinkage values for the various plastics are given in the data sheets in Section 5 of this issue.

Wall thickness—Strength required both in service and during manufacture must be considered in designing wall thickness. In thermosetting materials, walls less than 0.062 in. thick are extremely difficult to obtain, and a minimum of 0.125 in. is preferred (see accompanying table).

Draft—A draft taper in deep drawn parts, in addition to making it easier to remove a part from the mold, creates a wedging action as the the mold is closed. When thermosetting materials are compression molded, converging tapers increase the density of the plastic in the upper sections. There are no precise formulas for taper, but the most liberal taper the design can allow should be provided. Tapers of less than 1 deg can be used for deep parts; e.g., television cabinets 6 to 24 in. deep have been molded with tapers as small as 0.001 in. per in.

Tolerances—A high degree of accuracy in molded parts is expensive to achieve. On small shapes, tolerances as close as ±0.002 in. are possible. When

Plastics Parts

size is increased to a few inches, over-all tolerances increase to approximately ±0.005 in. On large pieces, tolerances of about ±0.001 to 0.002 in. per in. are obtainable. Tolerances closer than actually mandatory should not be specified; as specified accuracy increases, cost increases disproportionately.

Design Rules.

1. Use sufficient draft on long thin shapes to permit their withdrawal from the mold.

2. Minimize coring. When cores are used they should be easy to withdraw.

3. Avoid internal and external undercuts; they make withdrawal of parts difficult and require considerably more expensive molds.

4. Provide ample fillets on inside corners, and avoid sharp external edges and corners except at the parting line of the die.

5. Avoid large flat areas. Dappling or otherwise breaking up the surface is recommended.

6. Keep tolerances as liberal as possible. Excessively close tolerances add to cost because of increased die costs and high rejection rate.

7. Avoid abrupt changes in wall thickness.

8. Locate parting lines so that flash can be removed easily without marring surrounding areas.

9. Locate holes for easy coring.

10. Use ribs to achieve desired strength and stiffness. Ribs permit materials savings by reducing section thickness.

11. Use inserts for threaded holes where high stresses are anticipated or where considerable wear is to be encountered. Round inserts are preferred.

WALL THICKNESS OF MOLDED PARTS (In.)

Material ↓	Minimum	Small Parts	Average	Large Parts
THERMOSETTING				
Phenolics				
General Purpose & Flock-Filled	0.050	0.062	0.125	0.187–1.000
Fabric-Filled	0.062	0.125	0.187	0.187–0.375
Mineral-Filled	0.125	0.125	0.187	0.200–1.000
Alkyd				
Glass-Filled	0.040	0.093	0.125	0.187–0.500
Mineral-Filled	0.040	0.125	0.187	0.187–0.375
Ureas, Melamines				
Cellulose-Filled	0.035	0.062	0.100	0.125–0.187
Fabric-Filled	0.050	0.125	0.125	0.125–0.187
Mineral-Filled	0.040	0.093	0.187	0.187–0.375
THERMOPLASTIC				
Acrylics	0.025	0.035	0.093	0.125–0.250
Cellulose Acetate	0.025	0.050	0.075	0.125–0.187
Cellulose Acetate Butyrate	0.025	0.050	0.075	0.125–0.187
Ethyl Cellulose	0.035	0.050	0.062	0.093–0.125
Polyamide	0.015	0.025	0.060	0.093–0.125
Polyethylene	0.035	0.050	0.062	0.093–0.125
Polystyrene	0.030	0.050	0.062	0.125–0.250
Polyvinyl Chloride	0.093	0.062	0.093	0.125–0.250

Castings

Materials. Any resin available in liquid form can be cast. Castable resins include phenolics, polyesters, epoxies, silicones and acrylics.

Types of molds. The type of mold used depends on the plastic, the size and shape of the part, and other design considerations.

Draw mold—No undercut is possible. Flutes and scallops must run in the direction of removal. Taper must be provided to break the vacuum and reduce friction. Castings are removed by force, and minimum wall thickness is critical, running from 1/8 in. on tiny parts to 3/16 in. on parts the size of radio cabinets.

Split mold—Undercuts may be provided if they do not prevent release from the separate parts of the mold. Minimum wall thickness is 3/16 in., and parts less than 0.1 lb are not commonly produced economically.

Cored mold—This type allows complexity of design, but is not usually feasible from a cost standpoint for parts less than 4 x 4 x 4 in. Molds require no taper. Minimum wall thickness is 3/16 in. Mold shrinkage allowance must be considered. Extremely large parts may be cast.

Flexible mold—Model may be constructed of wood, porcelain, metal, etc. Mold is of plaster with a lining of rubber latex or an elastomeric plastic. Epoxy materials may be cast in flexible molds, but most polyesters react with the lining material. Although parts cast in rubber molds cannot be held to the tolerances possible with matched metal molds, a reasonable degree of accuracy is reproducible. For example, on cast phenolic parts dimensions can be held to about ±0.004 in. per in. The degree of accuracy obtainable on any part depends on the oversize allowance used in making the master pattern, the care with which the pattern is made, and the degree of accuracy attained in calculating amount of shrinkage during cure of the rubber mold and the cast resin.

Extrusions

In many cases, extruded parts are competitive with molded parts. Where many parts are required with a complicated cross section in one plane, the cross section can be produced by extrusion, and the parts formed by rapid, automatic cut-off to shape.

Thermoplastics. In extruding a thermoplastic, the molding powder is fed through a hopper to a chamber in which it is heated to plasticity at a controlled temperature. The plastic powder is then driven, usually by a rotating screw, through a die having the shape of the desired cross section. The process is continuous and is used to produce tube, rod, film and sheet, as well as other continuous shapes.

Thermosets. Reinforced thermosetting tube and rod can be produced by an extrusion process. The reinforcing fibers are fed continuously through a bath of liquid thermosetting resin and then through a die of the desired cross section. The extruded shapes then pass through a cylinder held at a controlled temperature to polymerize and cure the thermosetting resin. Extrusion speed must be relatively slow to provide sufficient time for complete cure.

Thermoplastic Sheet Formed Parts

Materials. A variety of shapes and forms can be produced by thermoforming calendered, cast or extruded thermoplastic sheet. The materials that lend themselves to this method of forming include polystyrene and modified polystyrenes, acrylics, cellulose acetate and cellulose acetate butyrate, vinyl polymers and copolymers, and polyethylene. Use of this type of molding has grown with the development of relatively low cost extruded sheet to replace more expensive cast or calendered materials.

Methods. Essentially, thermoforming involves preheating the flat sheet to 180 to 360 F, the temperature depending on the material, and then forming by mechanical, air or hydraulic pressure to the desired shape. After cooling, the part is taken from the mold, and unwanted flanges are sawed or blanked from the part. All of the different processes have in common low forming pressures, and thus low cost molds and equipment (see box on next page for details on the types of parts producible by each method). In recent years, rapid-cycle forming machines have been developed to make sheet molding more practical for large production quantities.

Reinforced Plastics Moldings

The term "reinforced plastics moldings," as used here and in the plastics industry, refers to parts produced by impregnating a reinforcing material, in the form of cloth or mat, with a liquid thermosetting or thermoplastic resin, laminating the material into multiple layers, and curing with heat and pressure to form a dense, hard solid. It does not include materials discussed later as "high pressure laminates," which are available from stock as flat sheet, rod or tube.

Materials. Resins used for reinforced plastics moldings include polyesters, phenolics, epoxies, melamines and silicones. Reinforcements include cloth or mat made from cotton, glass, asbestos and nylon. Glass reinforcements are most commonly used. Recently, there has been much interest in reinforcing thermoplastic resins, such as vinyls and acrylics, with cloth or mat made from thermoplastic synthetic fibers such as nylon. However, the bulk of reinforced plastics moldings today utilizes thermosetting resins.

Methods.

Contact molding—A low cost mold is used. Layers of reinforcing material are placed by hand against the mold surface; and resin is added, either by spraying or brushing after each layer is located. After sufficient layers of mat or cloth have been saturated with resin, they are allowed to harden without external application of heat and without applied pressure.

Vacuum bag molding—Procedure is similar to contact molding except that when lay-up is completed, a flexible sheeting, usually polyvinyl alcohol, is placed over the impregnated reinforcement and a vacuum is drawn between the sheeting and the mold surface. This provides about 12 psi pressure on the part, permitting higher glass content.

Pressure bag molding—Similar to vacuum bag molding except that a tailored bag is placed against the sheeting, and pressure is applied inside the bag to expand it against the impregnated reinforcement (sometimes pressure is applied directly on the sheeting). Pressures up to 50 psi are usually used, making high glass contents practical. Sometimes the entire assembly is placed in a large autoclave that contains hot air or steam at 50 to 100 psi pressure ("autoclave molding").

Flexible plunger molding—A metal female mold is usually employed and glass and resin are placed in the heated cavity. The plug portion is made of medium hard rubber, and is the approximate shape of the part to be molded. The rubber plug provides uniform, high and fluid pressure. High glass contents are possible. This method is not practical for large moldings because of the high pressures and the limitations of the flexible plunger.

Vacuum injection molding—Two molds, often made of glass-reinforced plastics, are used. The reinforcement is laid between the two molds and the resin is poured in a moat around the bottom. The resin is then sucked by vacuum up through the reinforcement. This tends to give air-free parts, and is used primarily for large parts. Glass contents are usually low.

Matched die molding—Can be used for parts up to about 60 sq ft in area, and is generally used for high production runs. Uses two metal molds which have a close-fitting, telescoping area to seal in the resin and trim the reinforcement. The molds are heated (with steam or electricity) to about 240 F. Where the length of run is sufficient, this method gives the lowest cost moldings and the highest production rates.

Design rules. Designing molded reinforced plastics parts is difficult because of the large number of variables encountered in the material and the process, and the difficulty of controlling some of them. These variables include: 1) composition of the resin, including fillers, catalysts and hardening agents, 2) geometry of the reinforcing material, 3) resin-reinforcement ratio, 4) degree of saturation of reinforcement by resin, and 5) temperature and time of cure.

The cardinal design rule, which cannot be overemphasized, is: consult the custom molder in the primary design stages. In addition, follow these general design rules:

1. Integrate parts.
2. Make prototypes.
3. Mold to dimensions; parts cannot be "sprung" after they are molded.
4. Use stress formulas valid for fiber-reinforced plastics.
5. Know the conditions of use.
6. Consider effects of the molding procedure.
7. Use sandwich construction for maximum strength-to-weight ratios.
8. To increase rigidity in stressed areas: a) increase the glass loading, b) use unidirectional reinforcement where practical, c) place flanges and lips on edges, d) use ribs, corrugations, beads and dimples, e) increase wall thickness, f) use curved sections rather than flat areas where possible, and g) use sandwich construction.
9. Avoid drastic changes in wall thickness.
10. Avoid sharp corners; use liberal radii.
11. Use maximum draft.
12. Avoid undercuts.

continued on next page

Plastics Parts

Thermoplastic Sheet Forming Methods

Cold bending. Simple circular or cylindrical shapes. The thicker the sheet, the larger the bend diameter must be to prevent high stress concentrations. Ex: consumer packages.

Hot line bending. Two-dimensional shapes with arc, angle or channel cross section. Gradual to sharp bends, depending on heating procedure. Ex: safety guards.

Stretch forming (hot draping, yoke forming). Two-dimensional or slightly compound shapes, especially large shapes. Subject to surface distortion. Not suitable for reproduction of fine details. Yoke forming provides more uniform thinning out and is suitable for longer runs than manual stretch forming. Ex: aircraft canopies.

Plug and ring forming. Shallow to deep drawn shapes with gradual to sharp angles and curves. Not suitable for highly accurate contours or fine mold details. Considerable surface distortion, especially at inside corners — unsuitable where optical properties are critical. Ex: trays.

Slip forming. Same as yoke forming or plug and ring forming except that much more uniform thickness and less optical or pattern distortion can be obtained throughout the part, especially in deep drawn shapes. Fluted edges obtained by increasing clearance. Ex: carrying cases.

Free blowing or free vacuum forming. Somewhat modified surface tension shapes (tending toward fishbowl shapes) determined by shape or clamping ring and depth of draw. Internal flanges. Tolerances ¼-½ in. Good optical properties. Vacuum method easier to control and preferred where 15 psi is sufficient pressure. Ex: aircraft domes.

Ridge forming. Simple or complex (with vacuum and/or air pressure) shapes with minimum surface distortion and low mold cost. Generous radii necessary to avoid tearing at ridges during forming. Combines possibilities of plug and ring forming, free blowing or free vacuum forming, vacuum forming and vacuum snapback forming. Ex: equipment housings.

Vacuum forming or blow molding in female mold. Usually limited to relatively shallow draws, and relatively large angles and radii—more so the thicker the sheet. Blow molding offers higher pressures and is therefore more suitable for smaller angles and radii, especially in thicker sheet; also reduces forming temperature required for thick sheet. Both produce some surface distortion—less so the more the shape of the mold resembles a surface tension shape. Ex: display signs.

Blow-dieing. Small, thin shapes having greatest perimeter larger than neck — especially closed spherical or modified spherical shapes. Not suitable for close tolerances. Ex: hollow toys.

Vacuum forming over male plug (drape forming). Shallow to deep drawn shapes with relatively sharp angles and curves can be made with good accuracy and reproduction of fine mold detail, and without excessive thinning out. More accurate than plug and ring forming but not as suitable for thick sheet. Subject to surface distortion, especially at bottom of draw. Ex: display signs.

Vacuum snapback forming. Especially suitable for modified surface tension shapes with minimum mark-off and closer tolerances (⅛ in.) than obtainable in free blowing or free vacuum forming. Simple snapback method not suitable for reverse curves or sudden contour changes, but more complex shapes and finer reproduction of mold detail are provided by additional vacuum or air pressure. Integral flanges. Combines possibilities of free vacuum forming and plug and ring forming. Ex: aircraft domes.

Matched die molding (embossing). Especially suitable for shallow draws, long runs and embossed surfaces. Relatively uniform thickness, good mechanical properties. Subject to surface distortion on both sides. Ex: watch crystals.

Die pressing. Small, simple shapes that can be approximated in precut blank and have somewhat varying thickness, or relatively great thickness compared to over-all size. Ex: brush backs.

13. Consider use of molded-in holes.
14. Consider mold shrinkage.
15. Design to practical dimensional tolerances.
16. Design to avoid warpage.

Secondary fabrication. See "High Pressure Laminates" below.

High Pressure Laminates

The term "laminates" used here refers to those reinforced plastics materials formed by high pressures (over 1000 psi). Vulcanized fibre is also included because of the similarity of its applications. These materials are available as sheet, rod or tube.

Materials. Resins used include phenolics, melamines, silicones and epoxies, and reinforcements consist of

MINIMUM COLD BENDING RADII FOR RIGID VINYL SHEETS

Calendered		Planished	
Thickness, in.	Min Bend Rad., in.	Thickness, in.	Min Bend Rad., in.
0.005			
Long	½	0.010	12
Trans	2	0.020	12
0.010		0.030	14
Long	1	0.040	14
Trans	6½	0.050	18
0.015			
Long	3		
Trans	9		

cellulose paper, asbestos paper, or fabric or mat made from cotton, glass, asbestos or nylon fibers. Vulcanized fibre has only one component—cellulose. It is made by laminating chemically gelled paper, leaching out the chemical, and calendering. The resulting laminate is tough and hornlike, and has good electrical properties. Properties of standard NEMA (National Electrical Manufacturers' Assn.) laminates are given in Section 5 of this issue.

Postforming. Certain grades of laminates can be postformed by the use of heat and pressure. Temperatures, times and pressures vary with grade of laminate, thickness of material, and design. Temperatures generally range between 350 and 480 F, heating time usually ranges from a few seconds to a few minutes at most, and pressures range from a few pounds to several hundred pounds per square inch.

Although the following formability values should not be used for design, they do indicate general limits for postforming. Minimum radii are measured on the inside of bends, and apply to bends made lengthwise and crosswise. Smaller radii can be achieved with cloth-base laminates by orienting the sheet so that bends are made diagonally to the warp and fill directions.

Thickness, in.	Min Bend Rad., in.
1/32	1/32
1/16	3/32
3/32	3/16
1/8	5/16
3/16	9/16
1/4	1
5/16	1 3/4
3/8	2 1/2

Postforming grade laminates can be drawn to moderate depths. Both paper and cloth-base laminates in 1/16-in. thickness can be drawn to a depth of about 1¼ in. in a 3-in. dia spherical cup.

Vulcanized fibre can be formed by the use of moisture and pressure. Water softens or plasticizes the fibre to the extent that it can be formed under relatively low pressures, usually between 200 and 500 psi. In addition to forming in matched die presses, vulcanized fibre can be formed in standard sheet metal angle brakes and in punch presses if the design is simple and only a little moisture is required.

Secondary fabrication. Machining and other secondary operations carried out on reinforced plastics are similar for both low and high pressure moldings, as well as for laminates.

Blanking and punching—Use of a punch press with a hard, well-made blanking or punching die is the accepted production method for cutting flat stock, putting holes into side walls of moldings, and other piercing steps. Punching of reinforced plastics results in holes that are 0.002 to 0.010 in. smaller than the punch. Blanking gives parts 0.001 to 0.005 in. larger than the die. In each case, these values depend on a relation based on the thickness and the proportion of reinforcement. This "shrinkage" causes the material to seize the dies, so that a strongly loaded spring stripper mechanism is desirable. It has been estimated that a pressure of 20,000 psi (on the shear-edge area) is sufficient for blanking, punching and shearing.

Shearing—Shearing of ½-in. thick stock is quite feasible. For best results, the piece should have a width of at least twice the thickness of the parent stock. Shear gibs must be snug and blades sharp.

Sawing—Abrasive cutting wheels should be used whenever possible; rigid mounting of both the wheel and the work is important. A metal cutting blade, if used, should have coarse, offset, wide-spaced teeth.

Drilling—Accurately located holes on side walls are difficult to mold. Where small runs are made, and where precision is required, drilling is recommended. There is no limit to the thickness that can be drilled.

Tapping—Tapping is seldom performed, because the strength of a screw and tapped hole system is inferior to that of a nut and bolt assembly. Where light duty connecting is called for, self-tapping screws are satisfactory.

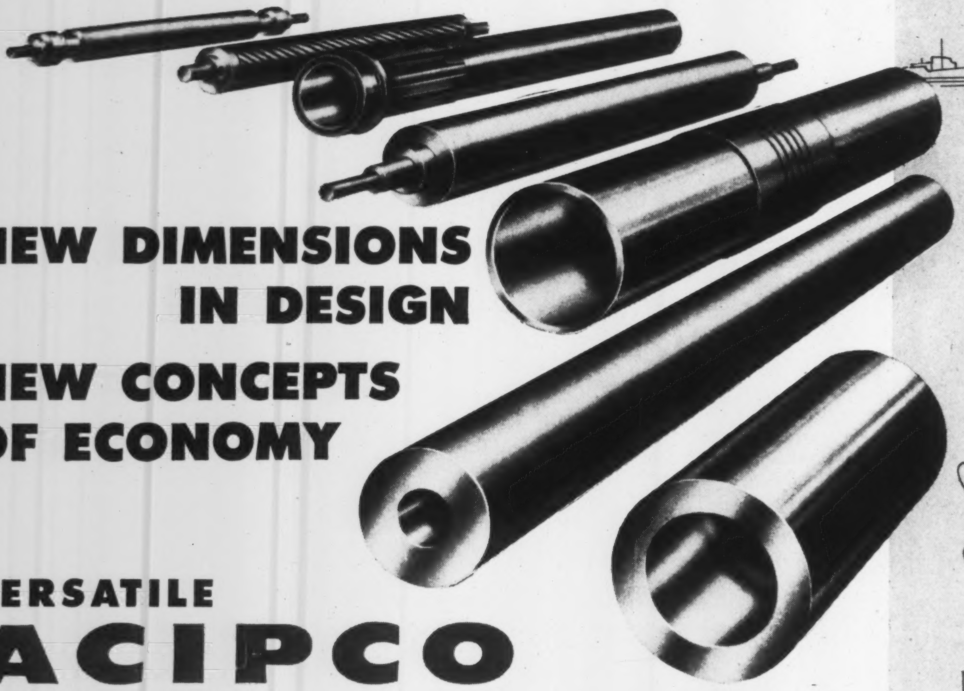
Grinding—Widely used to provide the taper in glass fiber-reinforced plastics fishing rods. Satisfactory automatic machines are in common use. Standard coolants are employed so that rapid feeds and minimized wheel loading are possible.

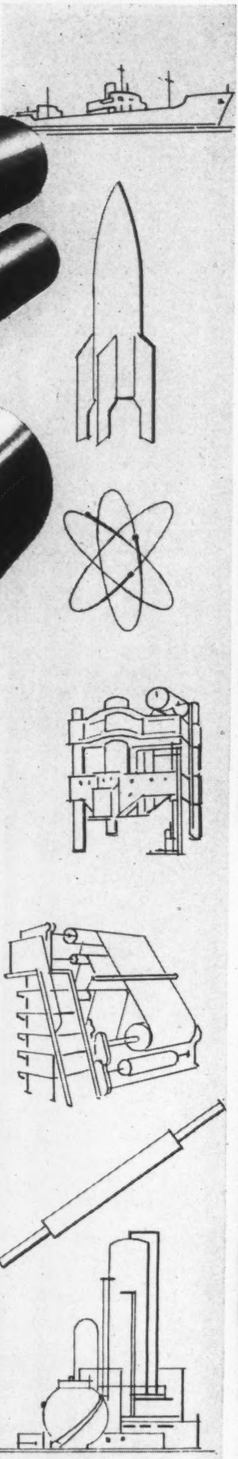
Routing, milling, turning—Routing is a practical production edging process and is faster and more accurate than jig-sawing where moderate numbers of irregular holes are to be cut. Milling and turning are not frequently required, but can be readily accomplished. Well-sharpened carbide or diamond-tipped tools provide good efficiency; speeds and feeds appropriate for brass are recommended.

DESIGN FACTORS FOR GLASS-REINFORCED PLASTICS MOLDINGS[a]

Type of Molding ➡	Bag	Flexible Plunger	Vacuum Injection	Matched Die
Inside Radius (min), in.	½	½	½	⅛
Molded-In Holes	Large only	No	No	Yes
Trimmed in Mold	No	No	No	Yes
Built-In Cores	Yes	Not rec	Yes	Not rec
Undercuts	Yes	Only slight	Not rec	No
Draft (min), deg	5	1	3	1
Thickness (min), in.	1/10	1/16	1/10	1/32
Practical Thickness (max), in.	1	¼	½	¼
Normal Thickness Variation, in.	±0.020	±0.015	±0.020	±0.008
Thickness Build-Up (max)	As desired	2 to 1 max	As desired	2 to 1 max
Corrugated Sections	Core better	Yes, 1-in. rad.	Yes	Yes
Metal Inserts	Yes	Not rec	Yes	Possible
Surfacing Mat	No	Yes	Not rec	Yes
Size of Part (max), sq ft	2000	100	1000	175
Metal Edge Stiffening	Not rec	Not rec	Not rec	Yes
Bosses	Possible	Possible	Possible	Possible
Fins	Yes	No	No	Short, yes
Molded-In Labels	Yes	Yes	Not rec	Yes
Raised Numbers or Letters	Yes	Yes	Yes	Yes

[a] Not rec=not recommended at present time.





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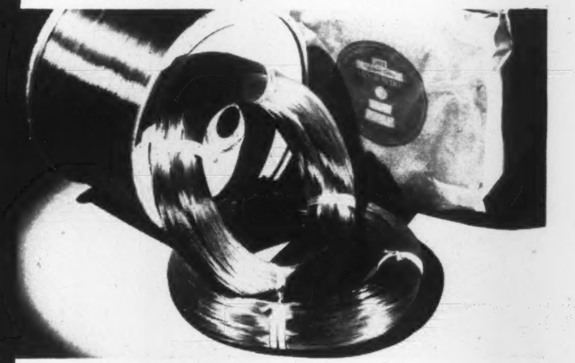

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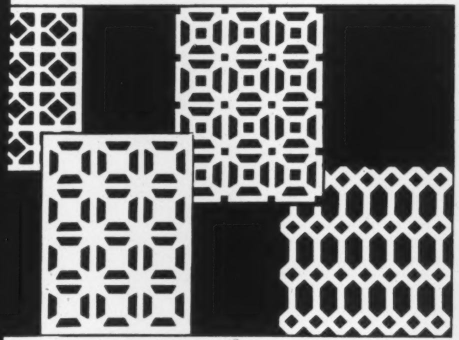

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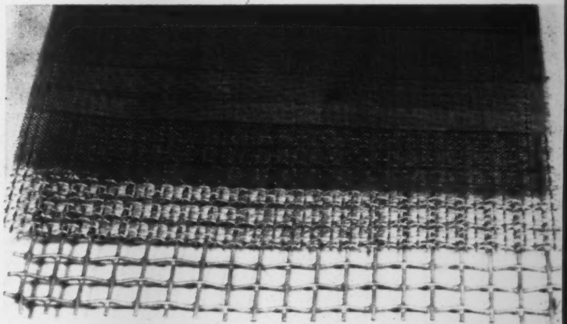

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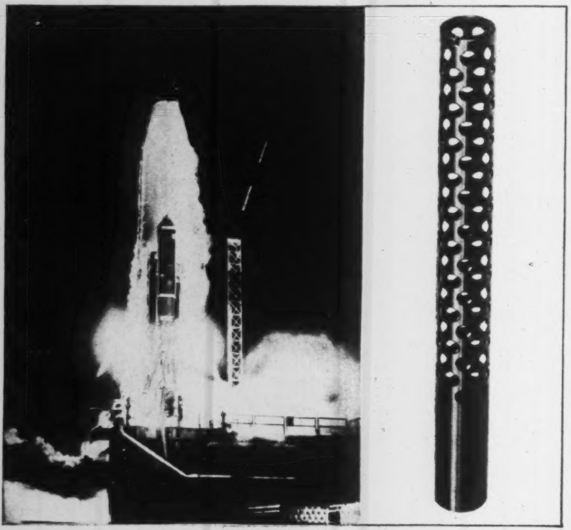

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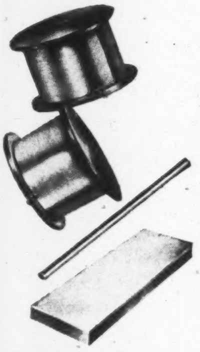

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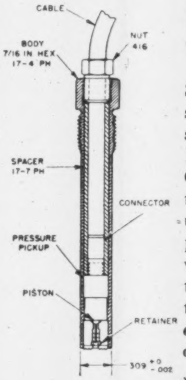

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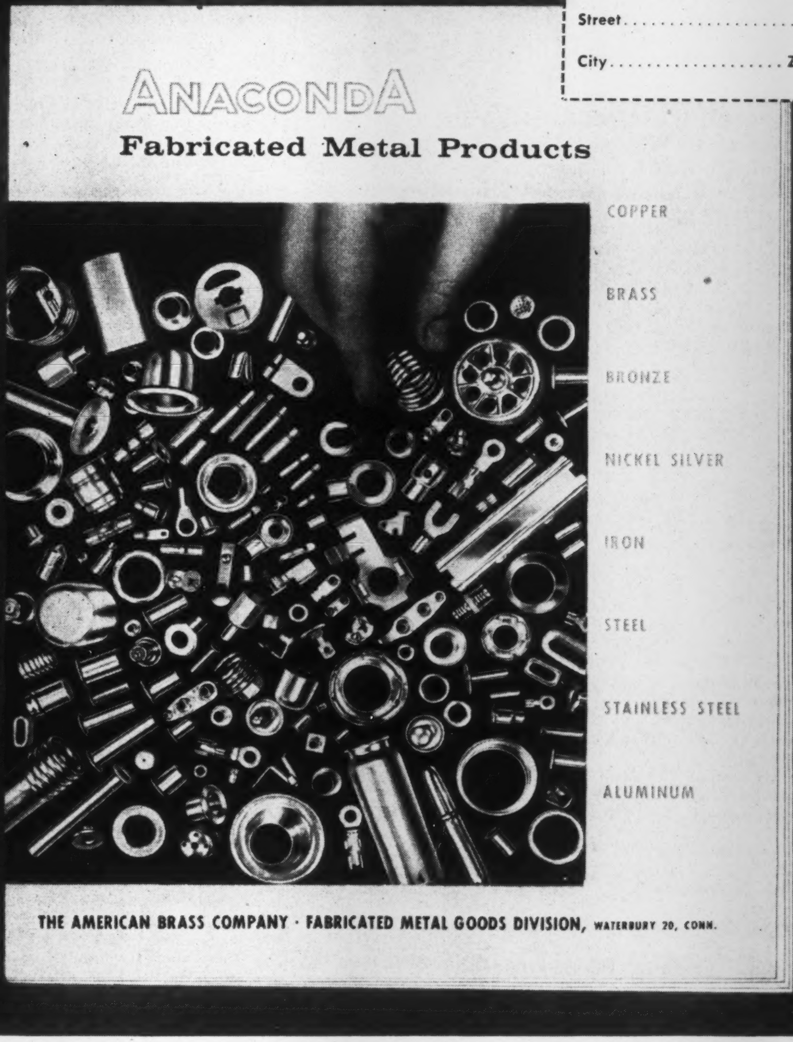

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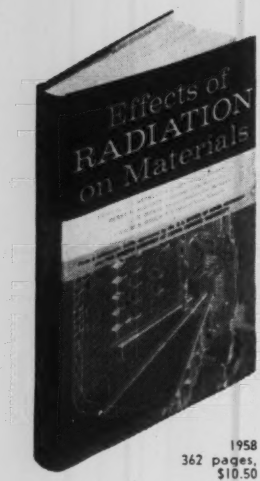

1958
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Effects of RADIATION on Materials

Edited by **J. J. HARWOOD,** U. S. Office of Naval Research; **HENRY H. HAUSNER,** Consultant to The Martin Co.; **J. G. MORSE,** Nuclear Div., The Martin Co.; and **W. G. RAUCH,** U.S. Office of Naval Research

The changes that radiation produces in metals, ceramics, plastics and a wide variety of other materials are thoroughly covered in this momentous new book. It contains the papers delivered at the radiation effects colloquium jointly sponsored by the Office of Naval Research and The Martin Company at Johns Hopkins University in March 1957.

Twelve leading authorities analyze the results of their own actual experiments with various materials. Solid state physicists classify fundamental and qualitative effects according to type. Metallurgists and chemical engineers make a quantitative evaluation of radiation effects on physical properties. The book also includes current concepts of radiation effects and discusses experimental approaches to radiation studies.

The outstanding authorship, and the subject's timeliness and importance establish this book as a milestone in technical literature. An extensive bibliography brings together the enormous amount of literature on the subject from every part of the world.

CONTENTS AND CONTRIBUTORS:

Defects in Solids and Current Concepts of Radiation Effects—G. J. DIENES, Brookhaven National Laboratory.
Experimental Approaches to Radiation Studies—Radiation Sources and Desimetry—J. C. WILSON, Oak Ridge National Laboratory.
Radiation Effects on Physical and Metallurgical Properties of Metals and Alloys—E. S. BILLINGTON, Oak Ridge National Laboratory.
Influence of Radiation Upon Corrosion Behavior and Surface Properties of Metals and Alloys—M. SIMNAD, General Atomics.
Effects of Radiation on Electronic and Optical Properties of Inorganic Dielectric Materials—R. SMOLOCHOWSKI, Carnegie Institute of Technology.
Effects of Radiation on Semiconductors—H. Y. FAN and K. LARK-HOROVITZ, Purdue University.
Cores, Liquid Coolants and Control Rods—C. E. WEBER, General Electric Co. (Knolls Atomic Power Laboratory).
Moderators, Shielding and Auxiliary Equipment—G. R. HENNIG, Argonne National Laboratory.
Experimental Techniques and Current Concepts—Organic Substance—M. BURTON, University of Notre Dame.
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Kennedy Van Saun Mfg. & Eng. Corp., Danville, Pa.
Lincoln Foundry Corp., Los Angeles, Calif.
Nordberg Manufacturing Co., Milwaukee, Wis. and St. Louis, Mo.
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Foundries of FMC, Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Washington Iron Works, Seattle, Wash.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

WRITE FOR YOUR FREE SINGLE COPY TODAY.

BULLETIN NO. 32
"MEEHANITE QUALITY CONTROL ASSURES UNIFORM DEPENDABILITY."

Write today to Meehanite Metal Corporation, Department MS 714 North Avenue, New Rochelle, New York.

MEEHANITE®

MEEHANITE CASTING DATA

The engineering properties of Meehanite castings provide a dependable material of construction. Combining the best properties of cast iron and steel, all Meehanite castings are produced by controlled processes to meet specific service requirements. There are more than 26 different types manufactured under four general classifications: General Engineering, Heat Resisting, Wear Resisting and Corrosion Resisting.

The metallurgical composition and structure of each type listed below is accurately pre-determined in the molten metal. Regulation of the quantity and disposition of graphite and the adjustment of the microconstituents permits achievement of the required properties.

This manufacturing control results in Meehanite castings which possess high strength, uniform solidity, true elastic properties, toughness, vibration damping, excellent wear resistance, self-lubrication qualities, free machining characteristics and the capacity to heat treat. If you have a casting problem, consult a Meehanite foundry today.

CLASSIFICATIONS AND SPECIFICATIONS OF MEEHANITE METAL

GENERAL ENGINEERING TYPES

Type	Tensile Strength Min. p. s. i.	Mod. of Elasticity p. s. i.	Compressive Strength p. s. i.	Shear Strength p. s. i.	Fatigue Strength p. s. i.	Brinell Hardness Section
GM	55,000	22,000,000	200,000	55,000	25,000	> 217
GA	50,000	20,000,000	175,000	48,000	22,000	> 207
GB	45,000	18,000,000	160,000	44,000	19,000	> 196
GC	40,000	17,000,000	150,000	40,000	17,500	> 192
GD	35,000	14,500,000	130,000	35,000	15,000	> 183
GE	30,000	12,000,000	120,000	30,000	13,700	> 174
GSP	80,000	24,000,000	160,000	65,000	35,000	> 207
GSF	60,000	23,000,000	120,000	55,000	20,000	> 161
GSH	100,000	25,000,000	....	....	....	> 227

HEAT RESISTING TYPES

Processed, according to type, to resist temperatures up to a maximum of 1650 deg. F. Tensile strengths at normal temperatures between 27,000 and 50,000 lb. p. s. i. Strength properties under elevated temperatures available on request.

HA	50,000	20,000,000	175,000	48,000	22,000	223
HB	40,000	21,000,000	162,000	42,500	19,000	300
HC	38,000	18,000,000	160,000	40,000	19,000	300
HD	38,000	18,000,000	160,000	40,000	18,000	300
HE	33,000	15,000,000	145,000	34,000	16,000	223
HR	30,000	10,000,000	....	31,000	....	223
SC	27,000	17,000,000	130,000	28,000	20,000	300

WEAR RESISTING TYPES

For resistance to hard surface wear. (Brinells to 578), a variety of Wear Resisting Meehanite castings provides types for specific wear problems. Poured under strict metallurgical control, physical properties are predetermined according to service requirements.

Type	Condition	Tensile Strength — p. s. i.	Brinell Hardness Number to specification
WAH	Heat Treated	Up to 70,000	200-600
WA	Sand Cast	Up to 50,000	193-321
Modified WH	Sand Cast	Up to 50,000	Up to 532
WB	Sand Cast	Up to 50,000	300-532
WBC	Chill Cast	Up to 45,000	Up to 500 on Chill Face
Standard WH	Sand Cast	Up to 30,000	Up to 575
WEC	Chill Cast	Up to 30,000	Over 444

CORROSION RESISTING TYPES

Used extensively in the chemical, metallurgical and oil refining industries to resist certain acids and chemicals.

Type	Tensile Strength p. s. i.	Modulus of Elasticity p. s. i.	Compressive Strength p. s. i.	Service	Brinell Hardness
CB_3	45,000	19,000,000	160,000	Concentrated Acids	197
CB	45,000	19,000,000	160,000	Acids & Chemicals	187
CC	40,000	19,000,000	160,000	Atmospheric	192
KC	32,000	14,000,000	130,000	Alkalies	197

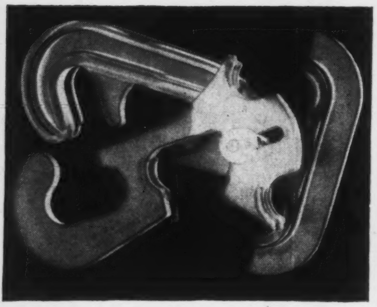
MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

MEEHANITE METAL

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

For more information, turn to Reader Service card, circle No. 615

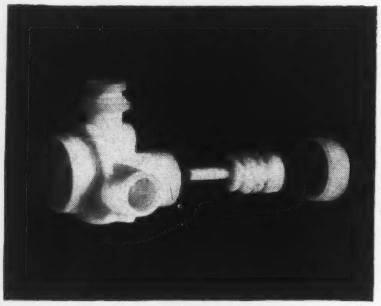
1 Nylon replaces metal in this idling cam. made by Chicago Molded for Holly Carburetor. By injection molding it of nylon, CMPC eliminated 3 operations—hardening, stamping, and assembly . . . cut production costs 50%. A unique mold design provides for easy changes in the number and sizes of ratchets at minimum expense. By any measure of value analysis, this is *designing for profit.* Think how this foresight could benefit your product, your profit.



2 This molded plastic suspension clamp, used for spacing power cables, has installation-ease and maintenance savings designed into its 4 integrated acrylic parts. The two-piece clamp body is fastened securely with a special bolt and nut, also acrylic. Injection molded, the clamp saves up to 60% of the cost of conventional systems—another example of designing for profit with plastics by CMPC.

3 Linear polyethylene replaces brass in this deep-well component injection molded by Chicago Molded for Red Jacket Manufacturing Company. By applying the right plastic material and molding method, CMPC solved a long standing corrosion problem and improved pump efficiency. Cost—a fraction that of brass with finishing eliminated. Perhaps you have a similar part or component.

5 *ways to design for profit with Chicago Molded plastic parts*



4 These injection molded nylon shapes compose a unique Venturi Valve unit used to regenerate the mineral bed of a Culligan Water softener. Previously, they were brass. By switching to Chicago Molded Thermoplastics, performance and durability were improved, material cost cut, machining and finishing eliminated. Your job may be smaller or very large, may require a different plastic, compression or transfer molding. For the right combination, call CMPC.

5 This transfer molded part is one of 10 Tormat memory blocks in the Seeburg Selectomatic 200 phonograph. The Chicago Molded body involves closest tolerances at 10 key spots on each side of the blocks. Fine detail and dimensional stability, good dielectric properties and high moisture resistance were basic material requirements met by CMPC. Our engineers can suggest ways to make your products better by designing in plastics . . . *designing for profit.*

DESIGN FOR PROFIT by consulting Chicago Molded engineers before committing your product to final drawings. They can show you how to make a good product even better, at lower cost through the use of custom molded plastic parts. Contact:

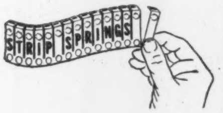
CHICAGO MOLDED
PRODUCTS CORPORATION
1026 North Kolmar Avenue, Chicago 51, Illinois

For more information, turn to Reader Service card, circle No. 534

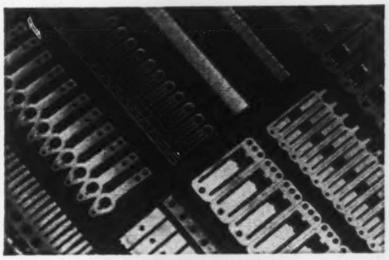
I-S SPRINGS of beryllium copper *can help you*

IMPROVE YOUR PRODUCT'S QUALITY, REDUCE YOUR COST, INCREASE YOUR PRODUCTION

Instrument Specialties Company specializes in the design and custom manufacture of age-hardened alloy springs. With our specially developed processes and machines, our engineers are able to realize the fullest performance potential from the superior spring materials around which I-S service to designers and manufacturers has been developed.

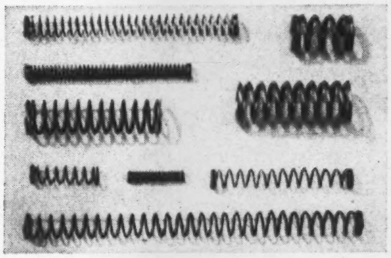


FOR HIGH PRODUCTION



STRIP SPRINGS

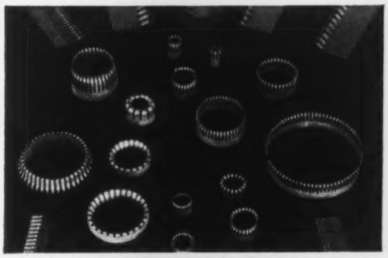
Fabricated from beryllium copper.
Easily handled, readily broken apart by hand or used in automatic or semi-automatic assembling devices and contact riveting machines.
Individual pieces may be broken off without trace of burr.
Eliminate sorting, untangling and handling of loose pieces.
Springs may be produced in strips to various shapes; formed angles may be held within plus or minus one degree.
Heat treated in multiple fixtures to insure uniformity, close tolerances and elimination of variations in spring-back.



COIL SPRINGS

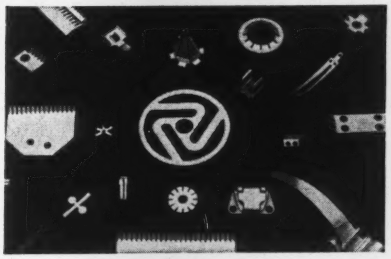
Made from laboratory tested beryllium copper wire.
Special coiling and heat treating equipment insures 100% uniformity.
Guaranteed rigid tolerances held on diameter and load tests at specified deflection.
These factors combine to assure increased service life through higher endurance strength – make products perform more consistently by eliminating drift, set or fatigue. Furthermore, they eliminate expensive hand adjustment and reduce inspection costs of finished product.

FOR LOW ACTIVITY



HIGH FREQUENCY SPECIALTIES

We are equipped to supply standard mating parts for use with 2C-39, 2C-40, 2C-43 and 3C-37 tubes, or custom made parts in related fields.
Grounding strips and contact fingers can be supplied in standard or special contours.
"Flea" contacts for co-planer type subminiature tubes and transistors.



SHORT-RUN SERVICE

For those who need quick delivery of parts in pilot quantities or require a low-cost proving ground for spring designs. I-S methods eliminate expensive tooling. Laboratory controlled, precision produced—yet at lower cost than is possible with permanent, high-activity tools.
We are equipped to handle conventional beryllium copper stampings and screw machine products in short runs or in high production.

"MICRO-PROCESSED" I-S BERYLLIUM COPPER SPRINGS

A COMPLETE ENGINEERING AND SAMPLE SERVICE

When your product is in the design stage, let us show you how I-S springs of beryllium copper may be designed to fit your needs. Ample stock, flexible facilities, short set-up time speed production of sample lots and trial orders.

INSTRUMENT SPECIALTIES CO., INC.

224-A Bergen Boulevard **Little Falls, New Jersey**
Telephone: Little Falls 4-0280

For more information, turn to Reader Service card, circle No. 459

Aico PRECISION MOLDED Plastics

coordinated facilities for molding all types of plastics under one roof saves time, cuts costs

AICO is a veritable one-stop shopping spot for all your molded plastics needs. At AICO you will find skilled technicians whose long and specialized experience keeps each job "on schedule" every step of the way . . . from design, through mold building, molding, final inspection and delivery. Regardless of molding material, molding method required or quantities involved . . . AICO is equipped to do the entire job. Under one roof, at AICO, you will find completely coordinated facilities to assure fast, economical production of all your custom molded plastics.

AMERICAN INSULATOR CORPORATION

NEW FREEDOM, PENNSYLVANIA

AICO'S COMPLETE PLASTICS MOLDING SERVICE INCLUDES:

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- COMPRESSION MOLDING
- PLUNGER MOLDING
- COLD MOLDING
- MOLD BUILDING
- TRANSFER MOLDING
- INJECTION MOLDING
- MOLDING OF REINFORCED FIBERGLAS

FREE TO HELP YOU MAKE BETTER USE OF PLASTICS

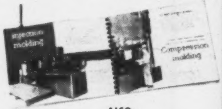
GOOD PLASTICS DESIGN

AICO PLASTICS DESIGNER'S HANDBOOK

Tells and illustrates how low unit cost can be achieved through proper plastics design.

AICO PLASTICS APPLICATOR

Tells molding material best suited for your product . . . tells how it should be molded.



AICO FACILITIES BOOKLET

Tells how to select a fully-equipped molder to do your job . . . shows how to avoid split responsibilities.

WRITE FOR YOUR FREE COPIES TODAY

For more information, circle No. 606

can you afford to gamble with quality on parts like these? . . .

BREAKER-POINT BODY for automobile-engine distributor
COMMUTATOR for electric motor
DISTRIBUTOR BAR for automobile-engine distributor

ACTUAL SIZE
(produced in one operation on high-speed multi-slide equipment)

Our customer list always includes world leaders in electrical and electronic products.

They depend on us year-in and year-out for stamped parts to match the quality they build into their products.

They refuse to gamble! . . . Can you afford to do so?

DE-STA-CO

DETROIT STAMPING COMPANY
Established 1915

419 Midland Ave. • Detroit 3, Mich.
America's Leading Job Stamping Manufacturer

Depend on Detroit!

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B&W JOB-MATCHED

TUBULAR PRODUCTS • EXTRUSIONS • WELDING FITTINGS

TUBULAR PRODUCTS
Seamless or Welded

Aircraft Tubing
Bearing Tubing
Boiler and Superheater Tubes
Condenser and Heat Exchanger Tubes
Dairy and Other Sanitary Tubing
Hydraulic Line Tubing
Mechanical Tubing
Pipe
Still Tubes

Types:

SEAMLESS TUBES—hot-finished, turned, cold-drawn, or roto-rocked

WELDED TUBES—from hot-rolled or cold-rolled strip, and cold-drawn

Shapes:

Round, square, rectangular, or special shapes

Grades:

Carbon, alloy, and stainless steels

Fabrication:

Upsetting, swaging, expanding, bending, safe-ending, and machining

EXTRUSIONS

TUBULAR SHAPES
SOLID SHAPES

Grades:

Standard and non-pierceable ferrous alloys, and non-ferrous materials such as Molybdenum, Zirconium, etc.

SEAMLESS WELDING FITTINGS

Elbows
Returns
Reducers
Tees
Caps
Stub Ends
Flanges
Saddles
Laterals
Bull Plugs
Nipples
Crosses

Grades:

Carbon, alloy, and stainless steels

SALES OFFICES

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BEAVER FALLS, PA..............712 Eleventh Street
BOSTON (Wellesley 81), MASS......66 Central Street
CHICAGO 3, ILL.....Room 800, 105 S. LaSalle Street
CINCINNATI 6, OHIO........2330 Victory Parkway
CLEVELAND 14, OHIO..1420 National City Bank Bldg.
DETROIT 26, MICHIGAN.........1717 Ford Building
HOUSTON 19, TEXAS............2134 Welch Street
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Warehouse stocks of B&W Seamless and Welded Tubing and Seamless Welding Fittings are maintained by distributors in principal cities

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MEXICO—C. Norman Frees—Buenavista No. 3, Despacho 505, Mexico 3, D. F.
PUERTO RICO—Portilla Corp.—P. O. Box 4349—San Juan 22

General Offices: BEAVER FALLS, PENNSYLVANIA • *Plants:* BEAVER FALLS, PA.—ALLIANCE, OHIO—MILWAUKEE, WIS.

TA8038-A

B&W

THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

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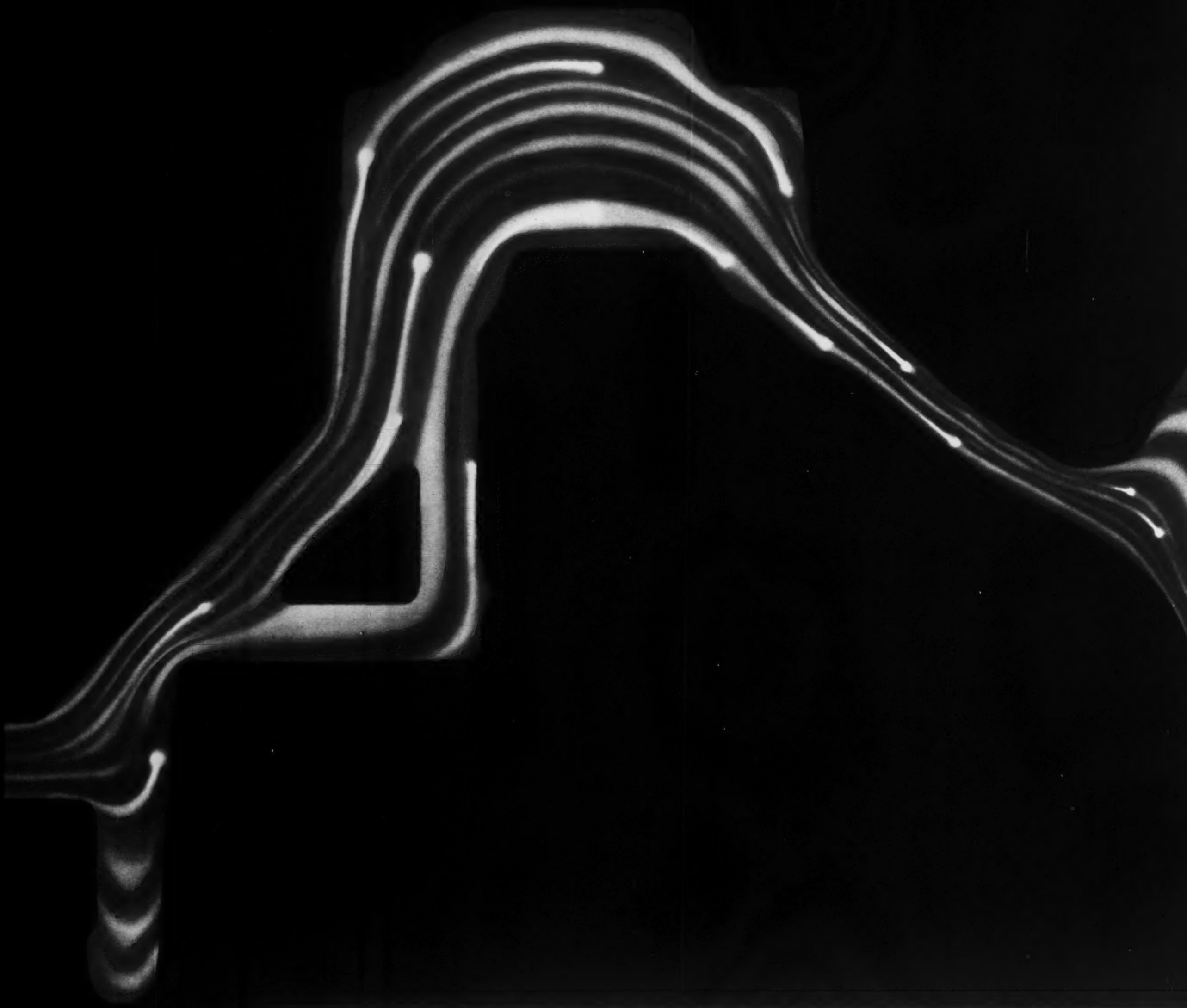


Fluid mapper pattern demonstrating liquid flow through a cross section of a Malleable differential carrier.

Versatility is Malleable

The ability to do most any job well is synonymous with Malleable iron castings. The variety of tasks they perform, from the commonplace to the spectacular, is legend. The strength and toughness . . . the freedom of design . . . the wide range of shapes and sizes . . . the excellent machinability . . . the economies achieved . . . all these advantages of Malleable combine to create an unexcelled reputation for versatility.

Whatever your needs, look first to Malleable.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

(Adertisement)

Versatility Is Key to Malleable's Increasing Use

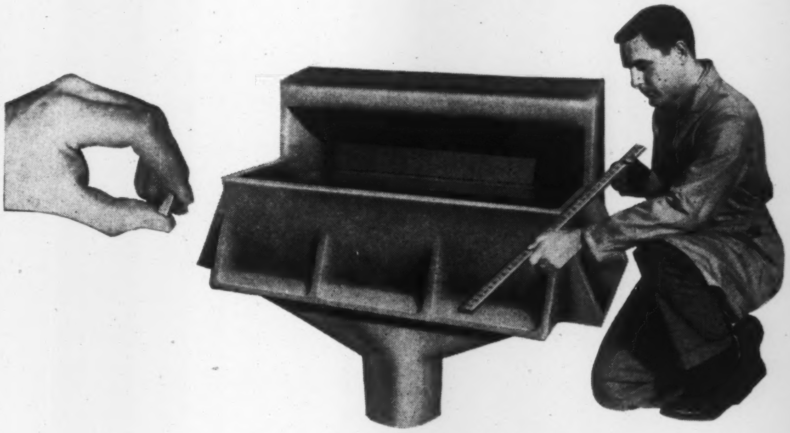
Recent metallurgical advances have made the Malleable irons a family of metals uniquely capable of meeting the most diverse design, production and performance requirements. Whether the vital consideration is high strength, toughness, ductility, hardness, machinability, high or low temperature performance, wear resistance, or economy and adaptability for complicated designs, Malleable castings have the versatility to meet exacting specifications.

For versatility of shape, the casting process is unexcelled. It permits direct production of the most complicated components. The metal is placed exactly where it is needed regardless of the intricacy of the design.

The capabilities of the metal to be cast are of even greater significance, for every application has a different set of requirements. Here, Malleable iron provides unique opportunities to obtain better parts at less cost.

Holes can be punched in Malleable, surfaces can be coined to meet rigid specifications. The pearlitic Malleables can be surface-hardened for even better wear resistance. These and other advantages make today's Malleable iron one of the most versatile engineering materials available.

Although Malleable iron's properties are flexible, depending on service requirements, certain relationships remain constant. Malleable provides more strength and toughness per dollar than any other metal. It is also the most machinable of all ferrous metals of similar properties.



Malleable castings can be produced in sizes ranging from the hammer handle wedge, shown here, weighing less than an ounce, to the 1,125 pound bridge scupper. Throughout this range is an endless variety of castings, best made of Malleable for highest quality at lowest cost.

Shapes and sizes of Malleable castings are virtually limitless. The combination of Malleable's good castability with modern production techniques regularly results in sections as thin as 1/16″ and tolerances of ±.005″ per inch in sections of 1″, with excellent surface finishes.

Engineering Aids Available

While the design of Malleable castings is not complicated, it will pay you to consult a skilled Malleable engineer who can offer time and cost saving suggestions for the production of better parts. As another aid to basic Malleable casting design, a special folder — *Data Unit 104 — Design Versatility* — is available from any member of the Malleable Castings Council and from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

These companies are members of the

MALLEABLE
CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division
Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 4

For more information, turn to Reader Service card, circle No. 477

WHY

ARE
ZINC DIE
CASTINGS
the most
widely used
?

because
the ZAMAK alloys have advantages over the other die casting materials...

WHY

has the use of
nonferrous
metal powders
increased
faster than
ferrous powders
?

because

HORSE HEAD PRODUCTS ®

HORSE HEAD brass and nickel silver powders have so many outstanding advantages

. . . bright, lasting finish at low costs
. . . range of alloys for controlled properties
. . . closer control of dimensional tolerances
. . . superior machinability
. . . excellent corrosion resistance without plating
. . . wide range of electrical properties
. . . attractive color

RANGE OF MECHANICAL PROPERTIES	ZINC ALLOYS	ALUMINUM ALLOYS	MAGNESIUM ALLOYS
Impact Strength	43-48, CHARPY (toughest)	2-8, CHARPY	1-2, IZOD
Tensile Strength	41,000-48,000 (strongest)	30,000-45,000	30,000-33,000
Shearing Strength	31,000-38,000 (toughest)	19,000-28,000	20,000
Elongation	7-10 (most ductile)	2-9	1-3
Brinell Hardness	82-91 (hardest)	50-80	60-62
CASTING CHARACTERISTICS			
Ease, Speed of Casting	(easiest)		
Maximum Feasible Size	(greatest)		
Complexity of Shape	(most complex)		
Dimensional Accuracy	(most accurate)		
Minimum Section Thickness	(thinnest)		
Surface Smoothness	(smoothest)		
COST			
Die Cost*	(lowest)		
Production Cost	(lowest)		
Machining Cost	(next to lowest)		
Finishing Cost**	(lowest)		
Cost per piece***	(lowest)		
EXTENT OF USE			
Extent of Use	(most used)		

*Dies for casting the low melting point alloys are least expensive and have longest life.

**Includes polishing and buffing expense as well as ease of applying all types of commercial finishes, both electrodeposited and organic.

***Based on die and fuel costs, production speed and machining and finishing costs.

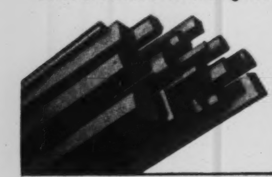
NOMINAL RANGE	HORSE HEAD BRASSES	HORSE HEAD NICKEL SILVERS
Copper	77-91%	64-70%
Nickel	—	10-18%
Lead	0-1.75%	0-1.5%
Zinc	remainder	remainder
PROPERTIES AND CONSTANTS		
Tensile strength	26,000-36,000	28,000-34,000
Elongation	10-27	10-15
Rockwell H Hardness	50-76	78-81
Electrical Conductivity	154,000-205,000	32,000

PRESSED BRASS
and other nonferrous
POWDER PARTS
ZINC
Die
Castings

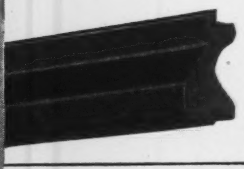
SEND FOR THESE USEFUL BOOKLETS

They will show you in detail how you can apply these cost-saving processes to your

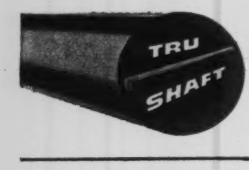
Brass & Bronze Free-Cutting Rods



Extruded Brass Shapes

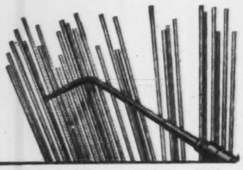


'Tru Shaft' Bronze Boat Shafting



Brass Wire

Bronze Welding Rods



Titan

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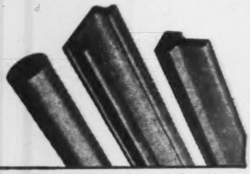

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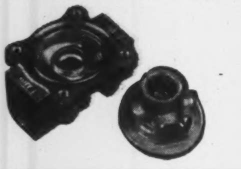

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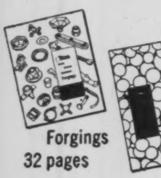

Rod Products
24 pages

Forgings
32 pages

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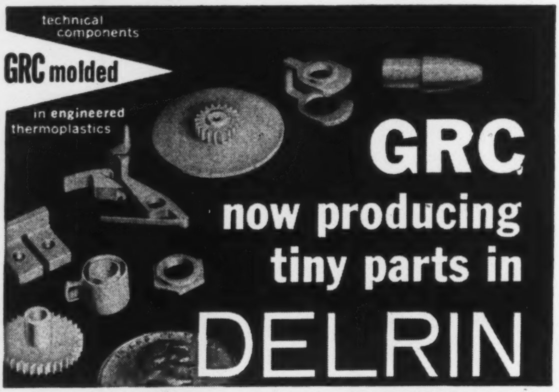

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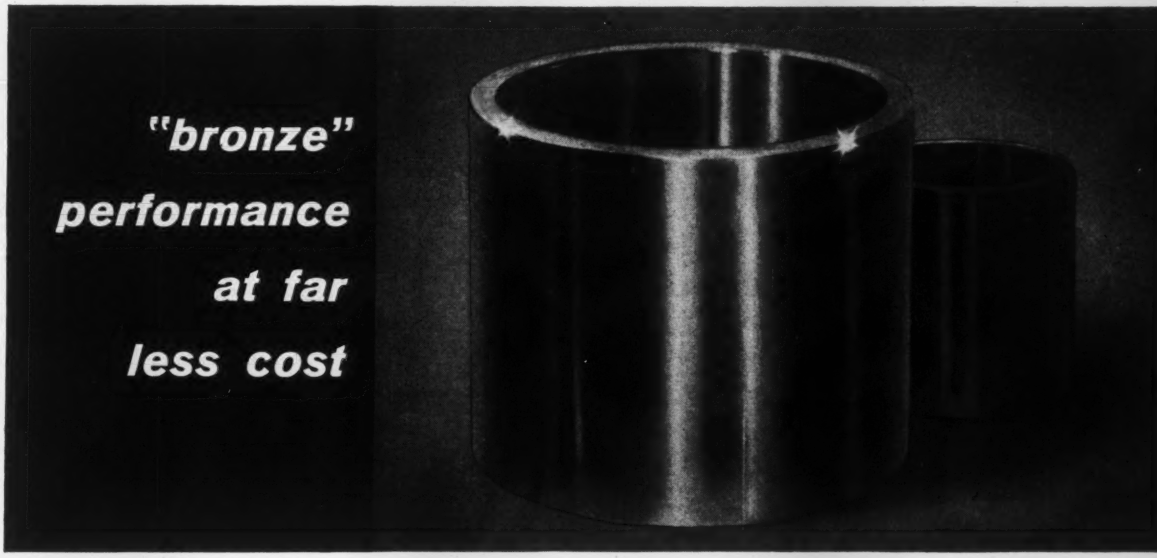

The important difference between the porous bronze bearing (right) and the all-new Iron OILITE* 212 Bearing (left) is cost. While both bearings give long, maintenance-free service, Iron Oilite 212 bearings now open the door to major savings for many equipment manufacturers.

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COMPARISON OF TYPICAL PHYSICAL PROPERTIES

	Iron Oilite 212	Oilite Bronze
Porosity, % oil by volume	18 - 23	18 - 23
Ultimate Tensile Strength, (psi)	10,000	18,000
Compressive Yield Point, (psi)	9,500	20,000
Rockwell Hardness	RH - 35	RE - 65
Specific Gravity	6.1 - 6.5	6.4 - 6.7

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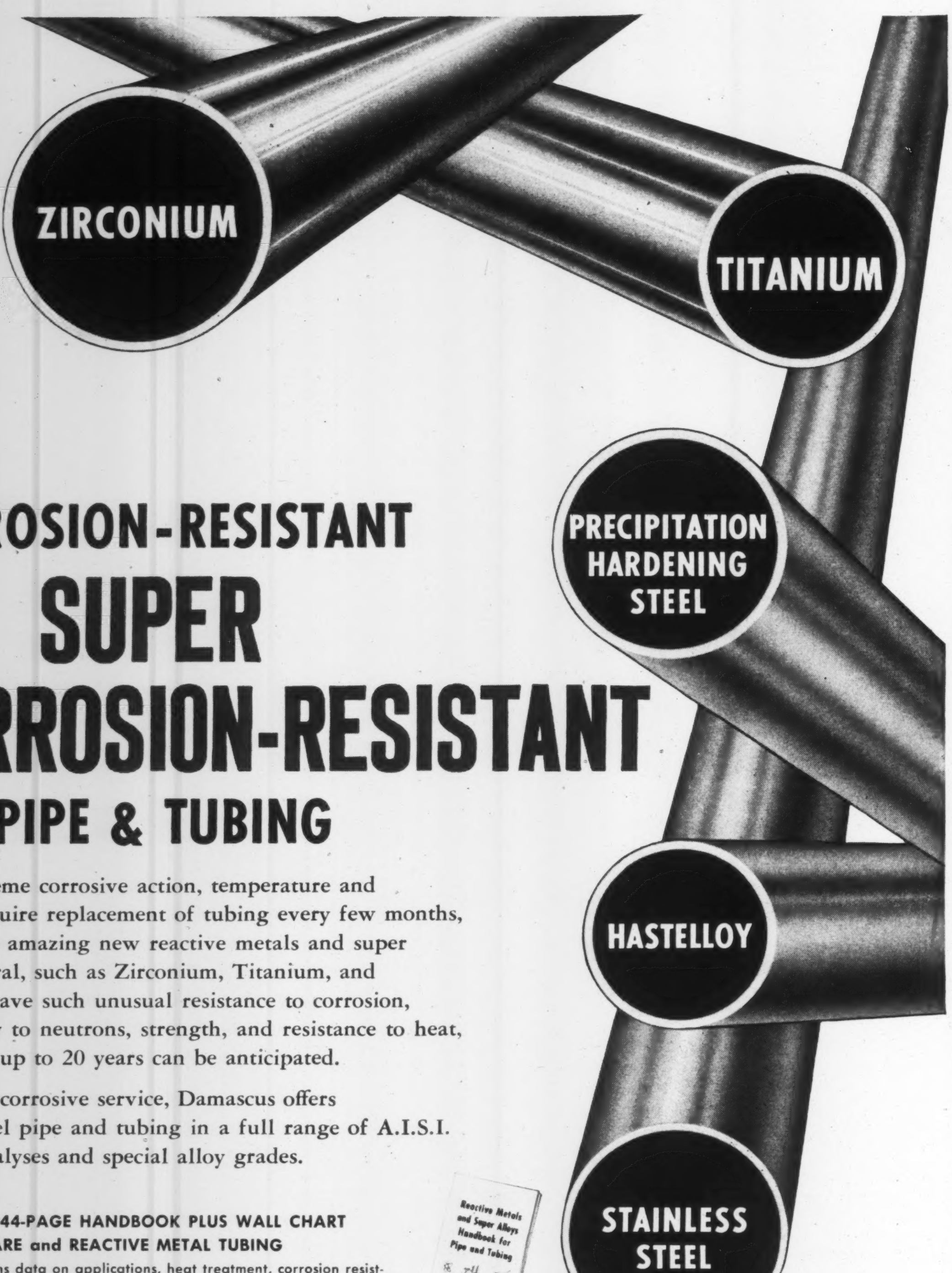

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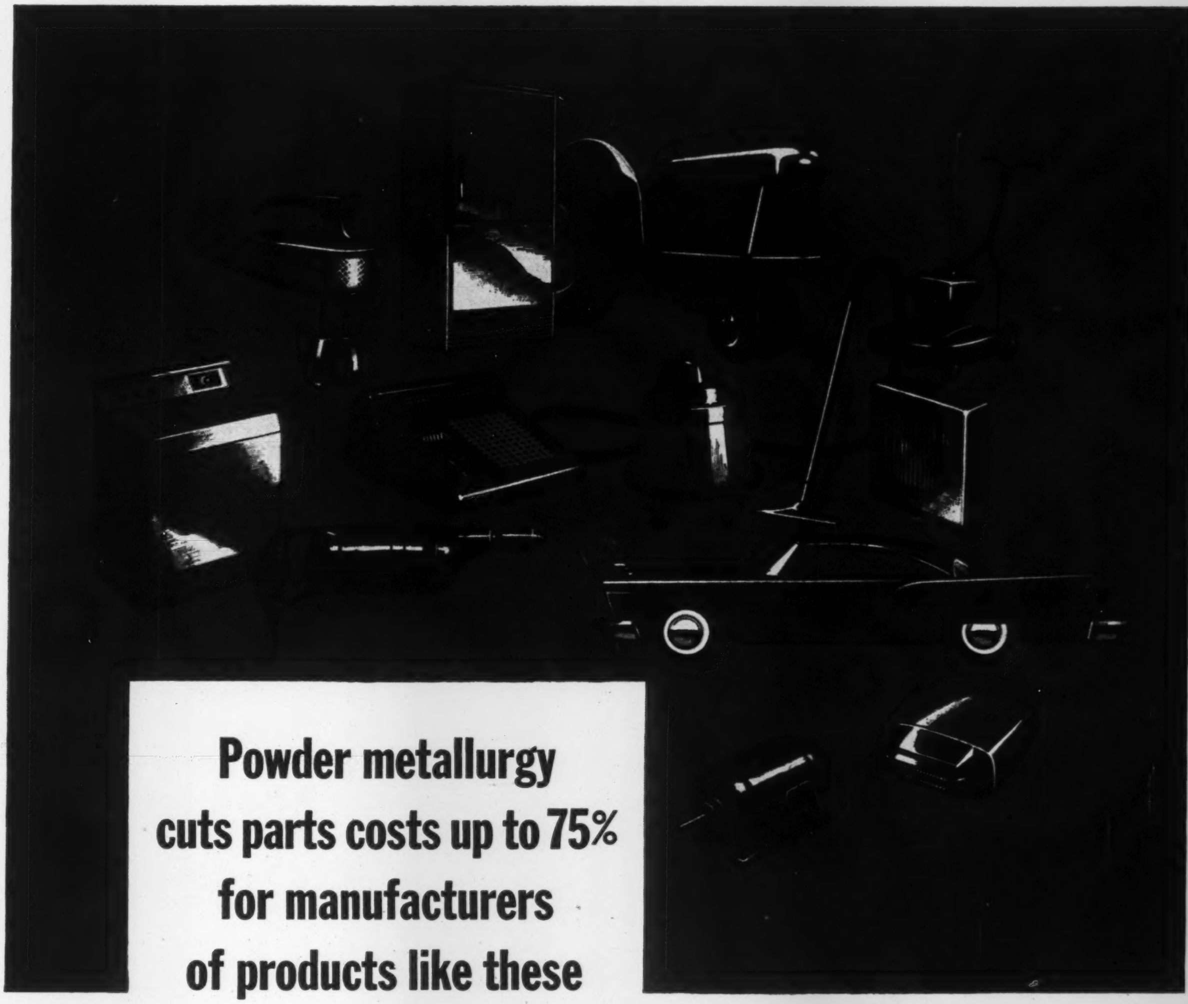

Powder metallurgy cuts parts costs up to 75% for manufacturers of products like these

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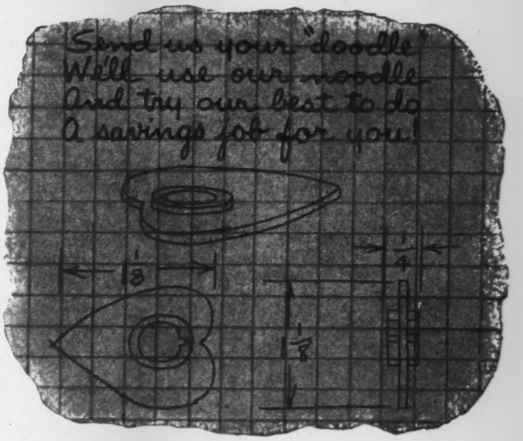

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Unitcast produces a complete range of cast steels, from plain carbon grades through the low alloy ranges—with subsequent heat treat service. Listed below are six basic steels produced by Unitcast. Variations or special steels on request.

CARBON STEEL CASTINGS

TYPE OF CASTING	PHYSICAL PROPERTIES Tensile Strength p.s.i.	Yield Point p.s.i.	Elongation In 2"	Reduction of Area	Brinell Hardness	GENERAL CHARACTERISTICS
LOW CARBON [Grade B Soft]	60,000	30,000	25%	40%	120-140	Comparable to SAE 1020. Ideal for carburizing purposes. Weldability excellent. High ductility.
MEDIUM CARBON [Grade B Medium]	70,000 [Min.]	38,000 [Min.]	24% [Min.]	36%	140-170	Comparable to SAE 1025. Good machinability. Above average physical properties. Weldability excellent. Good ductility.
MEDIUM HIGH CARBON [Grade B Medium High]	80,000	43,000	18%	30%	170-190	Comparable to ASTM-A-148-46T 80—40. Slightly higher carbon than "Medium" grade with higher tensile properties. Decreased ductility. Water quench will increase hardness. Pre-heating and post-heating recommended for welding.
HIGH CARBON [Grade B High]	85,000	53,000	17%	25%	179-217	Comparable to SAE 1045. Attained higher tensile properties result in slightly less ductility. Suitable for high surface hardness. Welding difficult unless pre-heated and post-heated.

ALLOY STEEL CASTINGS

PHYSICAL PROPERTIES*	HEAT TREATMENT Normalized Drawn	Oil Quenched 1200°F Drawn	Oil Quenched 900°F Drawn	GENERAL CHARACTERISTICS
T-LOY 34				
Tensile Strength p.s.i.	90,000	105,000	150,000	Comparable to SAE or AISI 8632. Oil quench produces excellent tensile strength properties ranging to 150,000 p.s.i., coupled with high ductility, wear resistance and immunity to temperature changes. Specific areas may be flame or induction hardened.
Yield Point p.s.i.	60,000	85,000	125,000	
Elongation in 2"	20%	17.0%	10.0%	
Reduction of Area	40%	35.0%	25.0%	
Brinnell Hardness	187-217	217-246	305-342	
T-LOY 42				
Tensile Strength p.s.i.	100,000	120,000	175,000	Superior to SAE or AISI 8640. Recommended when high strength and hardness are desired in the normalized and drawn condition. Deeper hardening obtained by oil quench and draw with tensile up to 175,000 p.s.i. High degree of hardness will be attained with spot or flame and air cooling. Water quench not recommended.
Yield Point p.s.i.	75,000	100,000	145,000	
Elongation in 2"	12%	12%	10%	
Reduction of Area	25%	28%	25%	
Brinell Hardness	217-246	250-280	350-380	

* Physical properties based on a .505" test bar turned from a standard 1⅛" cast test coupon

NOTE: Certified copies of complete test records—plus special test reports on each heat of steel—are provided to Unitcast customers on request.

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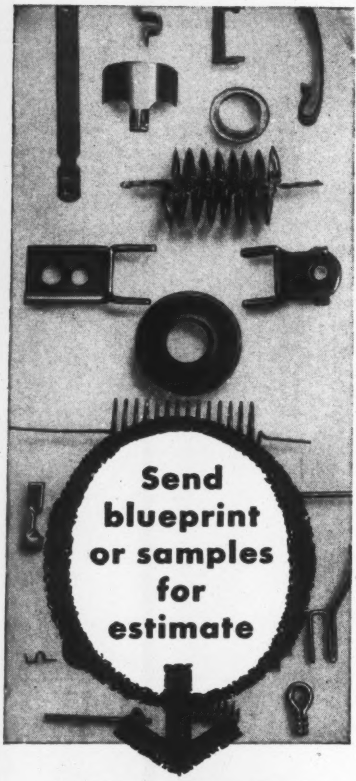

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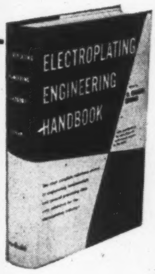

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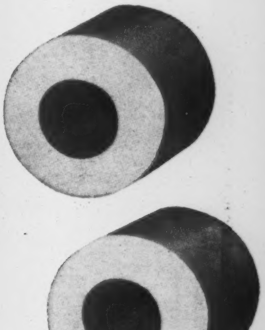

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More and more leading manufacturers are depending on Lewis for quality reinforced plastic moldings. Our trained engineers are ready to assist you in converting your product to this new material.

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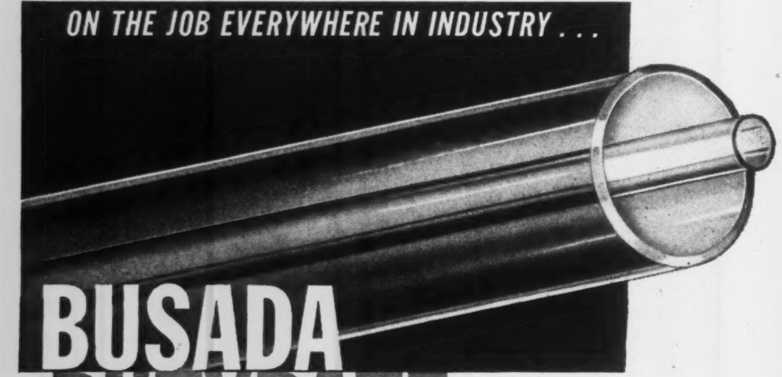

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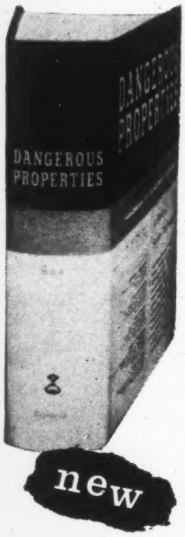

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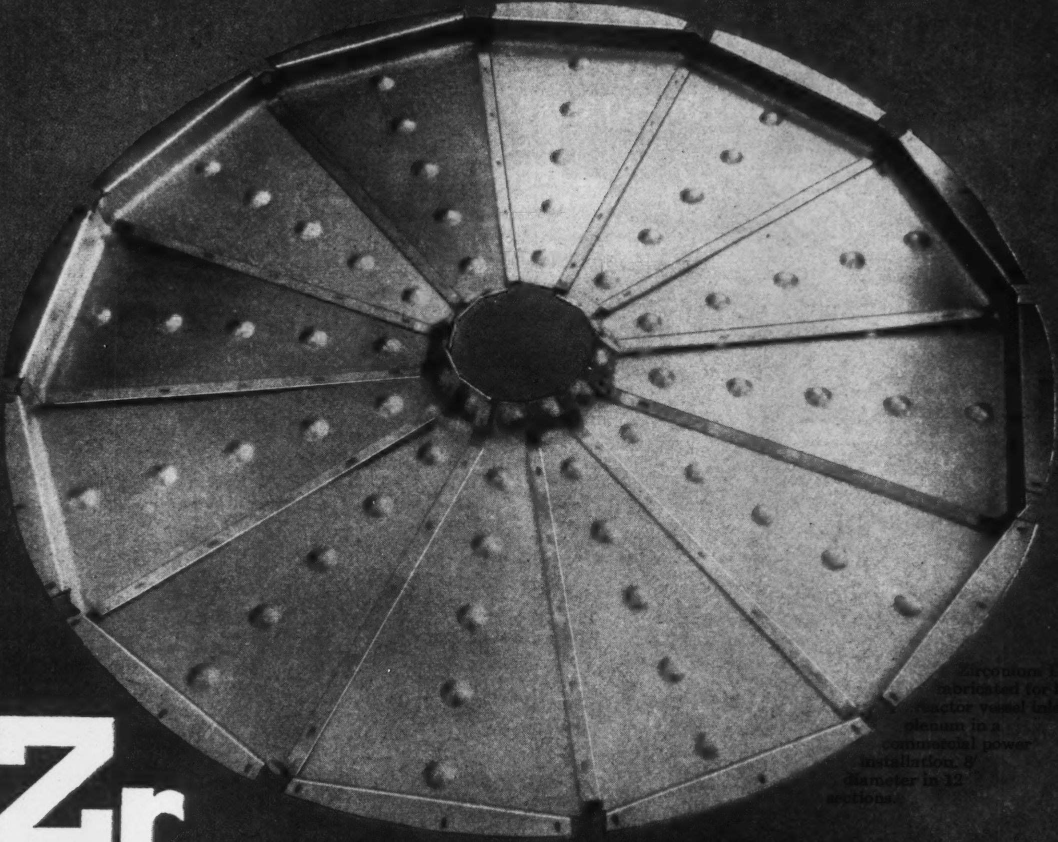

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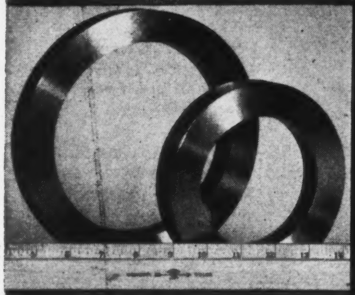

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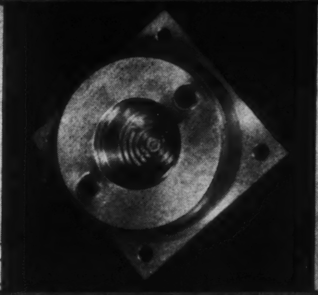

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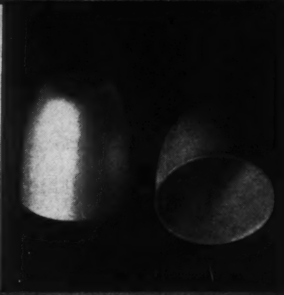

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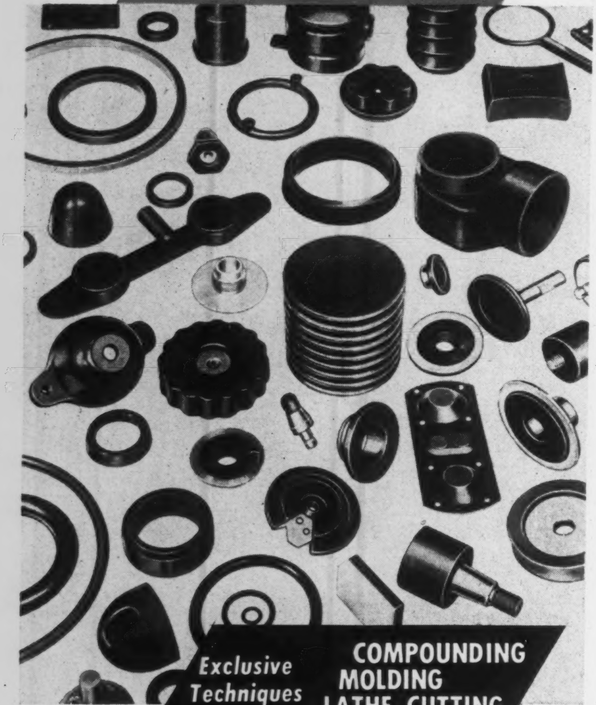

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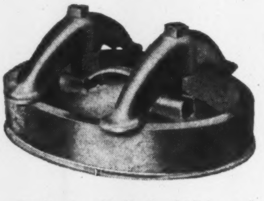

- Complete range of sizes from 4" x 6" to 18" to 24"
- Available in many materials
- LOW COST — assured by Lenape's specialized production methods

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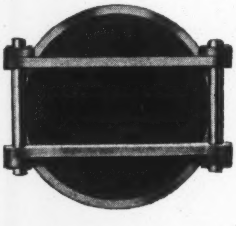

- Quick opening — remove only one pin
- Tight sealing — gasketed construction
- Sizes from 12" to 30" ID from 150# to 500#
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- Inherent reinforcement
- ECONOMICAL in first price . . . in cost of attachment and reinforcement

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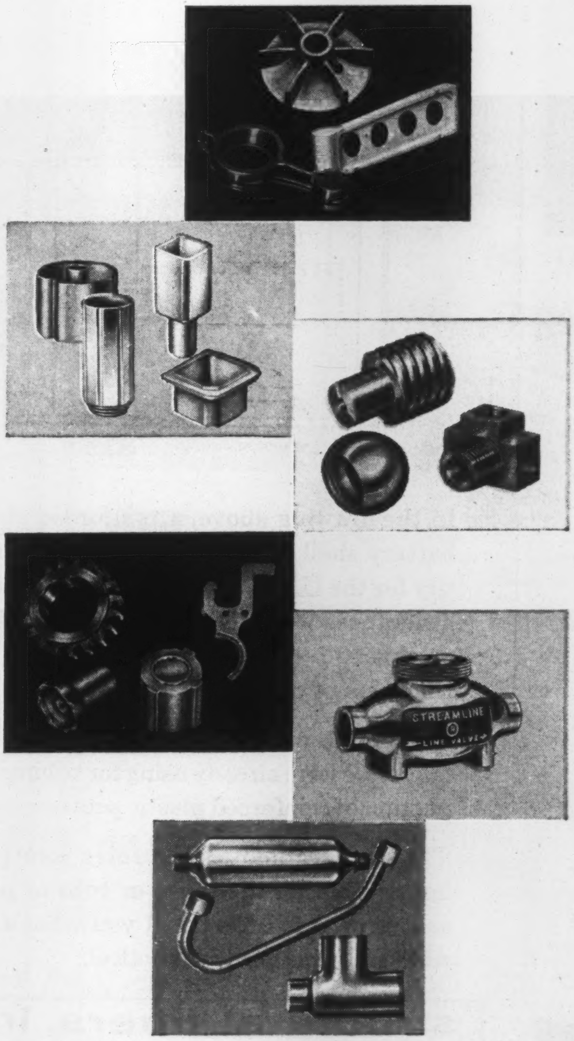

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The Mueller Brass Co. is the world's largest producer of brass, bronze and aluminum forgings.

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The Mueller Brass Co. now offers "Cold-Prest" non-ferrous and ferrous impact extrusions. Flexible new facilities makes practical either long or short production runs of simple or complex shaped parts on an economical basis.

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The Mueller Brass Co. maintains one of the largest automatic screw machine departments in the country, specializing in the manufacture of non-ferrous parts . . . completely equipped to perform secondary operations.

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Precision ferrous and non-ferrous powder metal parts are available from Mueller Brass Co. through its subsidiary, The American Sinteel Corporation.

castings

The Mueller Brass Co. has a modern foundry equipped to produce quality brass and bronze castings to your specifications.

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The Mueller Brass Co. offers complete facilities for producing formed copper tube shapes and assemblies to the most demanding tolerances.

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260

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share a mold–
divide the cost
AT ATLANTIC CASTING

Typical Atlantic Production Mold-Half (18" x 12")

PRODUCTION COSTS FOR PRECISION CASTINGS SHOWN ABOVE WERE SHARED BY THE FOLLOWING COMPANIES:

General Electric Company; Intertype Corporation; Westinghouse Electric Corporation; Air Reduction Corporation; United Shoe Machinery Corporation; I.T.E. Circuit Breaker Company; Ordnance Corps. Dept. of Army; Vonnegut Hardware Company.

PRECISION CASTINGS COST LESS AT ATLANTIC because production molds are shared by up to fifteen different customers and fifty castings. Standard production molds are produced and poured on a continuous basis and when an order for a casting is completed, the portion of the mold vacated is immediately utilized for another casting, while production proceeds without interruption.

TOOLING COSTS CUT!
Atlantic mold-sharing requires only one inexpensive, brass pattern, quickly produced and easily altered.

LABOR COSTS CUT!
Pouring as many as fifty castings in a single mold allows substantial reduction in labor costs per casting. This saving is passed on to you.

LEAD TIME CUT!
Continuous mold production with Atlantic's standardized interchangeable tooling allows immediate adjustments in scheduling to conform to your delivery requirements. Deliveries start in as little as two weeks on new orders—one week on reorders.

SEND OR CALL TODAY FOR ATLANTIC'S NEW CASTING CATALOG.

ATLANTIC
CASTING and ENGINEERING CORP.
810 Bloomfield Avenue • Clifton, N. J.
PRescott 9-2450

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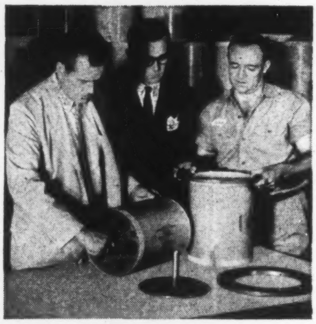
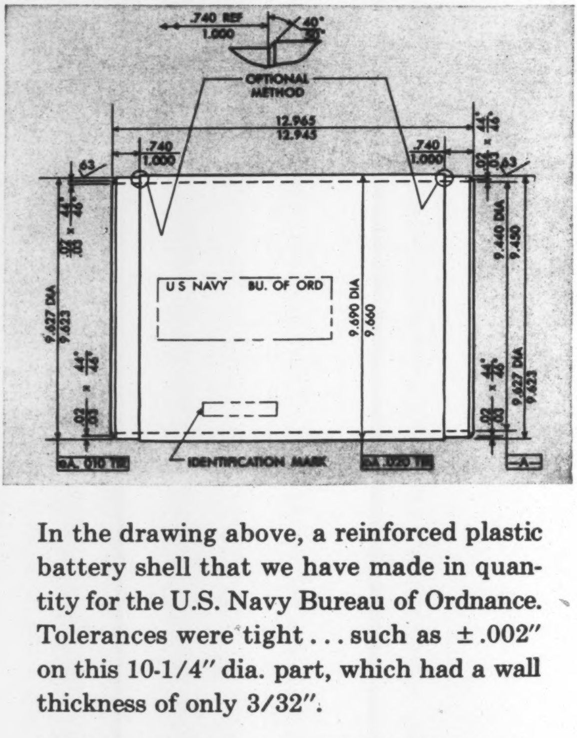
The Navy said



"CAN YOU"



In the drawing above, a reinforced plastic battery shell that we have made in quantity for the U.S. Navy Bureau of Ordnance. Tolerances were tight . . . such as ±.002" on this 10-1/4" dia. part, which had a wall thickness of only 3/32".

Production was successful, thanks to techniques we were already using for volume production of reinforced plastic pressure tanks.

The same techniques can solve *your* problems! Whether it's tanks or tubs or parts, call us or write. We'll tell you what's possible and whether it's practical.

structural fibers, inc.
FIFTH AVENUE • CHARDON, OHIO

REINFORCED PLASTIC PRODUCTS BY THREE PROCESSES:
- internal pressure molding
- matched die molding
- premix molding

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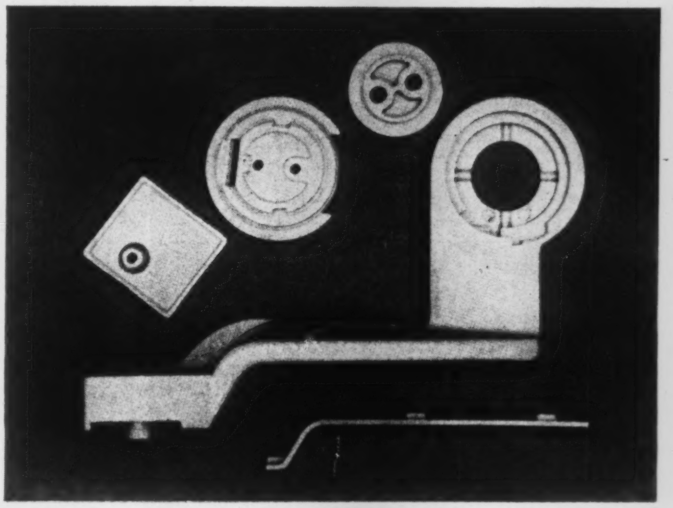
POLAROID
specified
dimensional accuracy

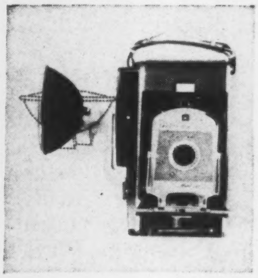


and got it from
CONSOLIDATED

Both dimensional accuracy and fine appearance were essential requirements in the production of this camera flash attachment for Polaroid. Naturally, mold planning and construction were of utmost importance in such a critical job. Precision and timing had to be built into the mold design. Three different molds were necessary to produce the five separate pieces which form one synchronized unit.

In assembling the unit, all parts had to be kept in perfect alignment; no warpage or twist was permitted. For appearance's sake, it was necessary to locate mold parting lines on the natural edges of the pieces.

This flash attachment unit represents the type of molding challenge Consolidated welcomes. We appreciate the opportunity to quote on any molding – complicated or simple.



The Polaroid Bounce Flash Bracket (Model #292), with swivel-type flash gun clip, permits the taking of both horizontal and vertical pictures without removing the gun to change its position.

For more than 80 years we have been filling exacting plastics orders for the nation's blue chip companies. Before you discard any design you feel can't be molded in a plastic, call Consolidated.

CMP

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WHEATLAND TUBE COMPANY

in this

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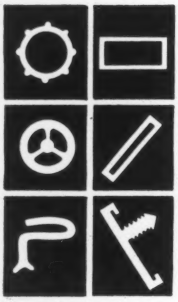

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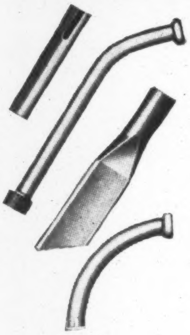

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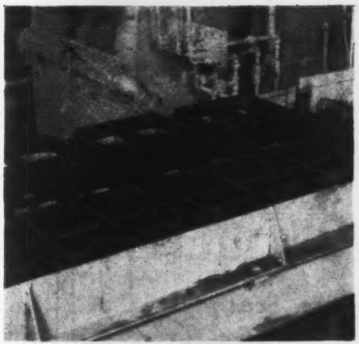

① HOM, a new alloy developed by Duraloy metallurgists and capable of retaining high working strength at temperatures up to 2200°F, with limited application at 2300°F. The alloy is applicable for all types of castings: static, centrifugal, shell-molded.

② Shell-molded castings for meeting close and rigid tolerance limits; post-casting machining or other finishing practically eliminated; low mass production costs.

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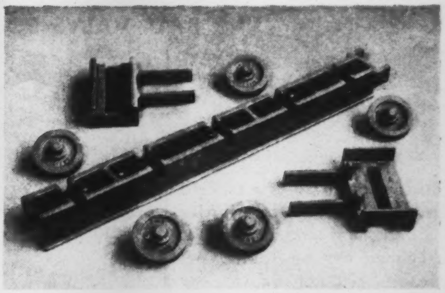
If the casting used in your equipment has to meet high temperature (anything up to 2300°F) and/or corrosion, why not discuss your requirements with our metallurgical staff? Our company can call upon more than 35 years of experience in this exacting business of high alloy castings. In the meanwhile, if you would like to have a copy of our latest catalog, write or call our nearest office.

③ Centrifugal castings which produce a denser, more uniform metal approaching forged metal strength.

④ Static castings which can be produced in weights ranging from a few ounces to single castings 7 tons and heavier; wide range of alloying combinations, including the new HOM referred to above.



Note *As a point of interest, all of the castings shown here were produced for Lindberg Engineering Company, Chicago, for incorporation in heat-treating and annealing equipment sold by that company. The centrifugally cast tube for the generator, trays, and rollers for the furnace rails are cast of HOM. The rails and rail supports for the furnace are statically cast of 35-15 alloy.*

ALLOY CASTING INSTITUTE ACI MEMBER

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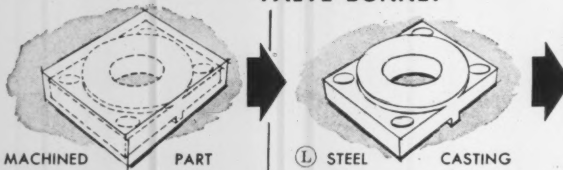
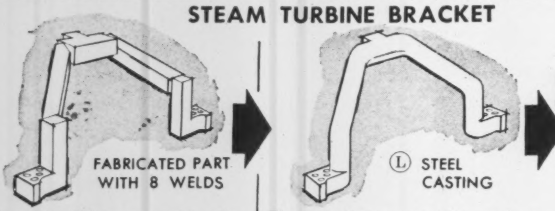


This 5" valve bonnet, for use in the chemical industries, was originally machined from stainless steel bar stock.

The part is now shell moulded, in high production quantities, cast to shape in stainless steel, with minimum machining.

SAVINGS OF 25%

STEAM TURBINE BRACKET



This part, 40" across, was originally produced by complicated and expensive fabrication involving 5 separate machined pieces and 8 welds.

The part is now cast in sand as one homogeneous unit, simplifying manufacturing and improving design.

SAVINGS OF 35%

Plus better dimensional control, better appearance.

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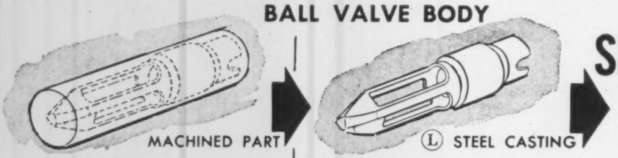

This component part for oil field equipment was originally hogged out of solid bar stock at a finished cost of $32.00 per unit.

The part is now cast, in the CO_2 process, at a finished cost of $18.00 per unit. Size 7" long.

SAVINGS OF 45%

Steel component parts now being machined, forged or fabricated can often be CAST BY LEBANON at considerable cost savings, with improved design and physical properties. Lebanon's Foundry Engineering Service will review your requirements and make specific recommendations if a conversion to steel castings can achieve lower costs for you.

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"Impact (Cold) Extruded Parts," 16 pp. Impact or cold extruding has been extended to the production of a wide variety of parts used in many industrial fields. This manual describes the process and discusses sizes, shapes, limitations and applications of parts produced from aluminum, magnesium, steels, and other nonferrous metals.

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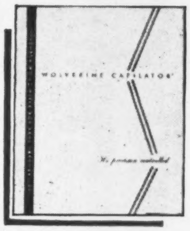
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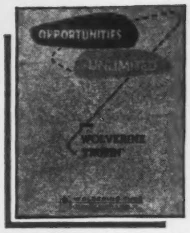
2. Wolverine Aluminum Catalog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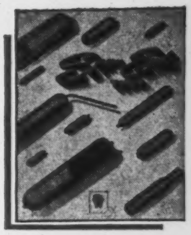
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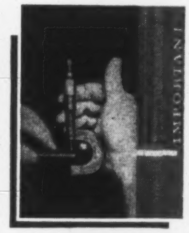
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When it comes to tube... come to Wolverine

10. Water Heater Catalog

From Wolverine Tube, manufacturers can obtain a great variety of tubular products. These range from such products as tiny, plug-drawn Wolverine Capilator® used for restriction purposes, to commercial copper tube up to 6 inch O.D. and aluminum tube to 3 inch O.D.

Illustrated on this page—and reading like tubing's "best seller" list—is the latest Wolverine Tube literature dealing with all the company's products and specialized services. Look these catalogs over. A request, on your letterhead, will bring you the catalog . . . or catalogs . . . of your choice without delay or obligation. Just write Dept. S—TODAY!

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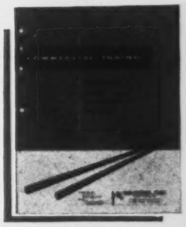
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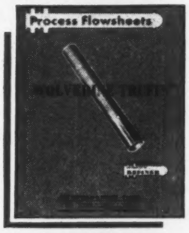
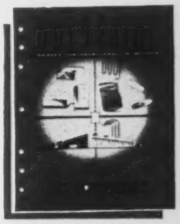

8. Process Flowsheets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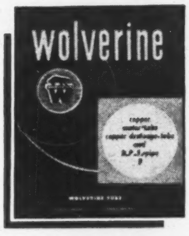
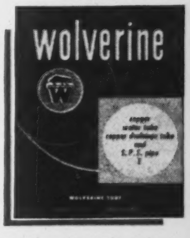

9. Copper Refrigeration Tube Book


13. Copper Water Tube Catalog

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14. Wolverine Corrosion Chart

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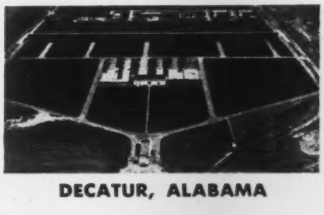
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15. Statement of Scope

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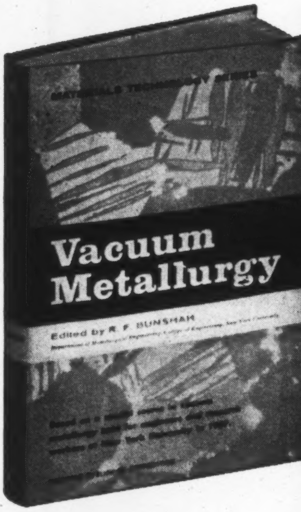

1958, 490 pages, $12.5

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The book encompasses virtually the entire field—production and measurement of vacuum; vacuum melting techniques (including the new electron bombardment); degassing of metals; and the metallurgical applications of vacuun processing to powdered and electronic materials, coatings, anc high temperature alloys. Much new material resulting fron basic research as well as that based on practical engineerin data is included. There is also a treatment of the specifi applications of the concepts of thermodynamics and kinetic to vacuum metallurgy and a discussion of future trends.

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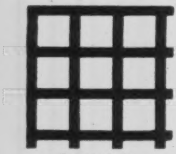

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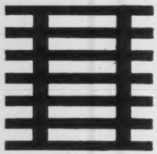
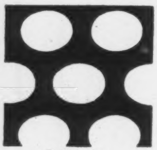


Slots



Oval holes

Types of FINISHES- Decorative sheets in aluminum can be delivered color anodized or with brushed finish. Steel sheets, painted, lacquered or Japanned. All decorative patterns can be embossed if requested.

Types of FABRICATING—Shearing, rolling, welding and forming services are available.

PERFORATED SHEETS CARRIED IN STOCK—Many patterns (industrial and decorative) are carried in stock at our warehouses for immediate delivery. Thousands of odd size pieces are also available if your requirements are small. SEND FOR H & K STOCK LIST BROCHURE.

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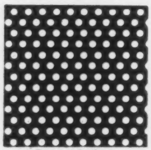
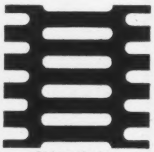
Types of MATERIALS—All metals—wood—plastics—cloth fabrics—paper. Facilities enable the perforating of materials furnished in sheets, coils, rolls or plates.

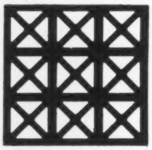
Types of PERFORATIONS—H & K has thousands of different die patterns to perforate round holes—slots—squares—triangles—oval shapes—burred, indented, tapered, stabbed, collared or lipped perforations—architectural grilles—louvres—decorative patterns—processing screens and precision sieves with tolerance held to ± .0005".



Round holes



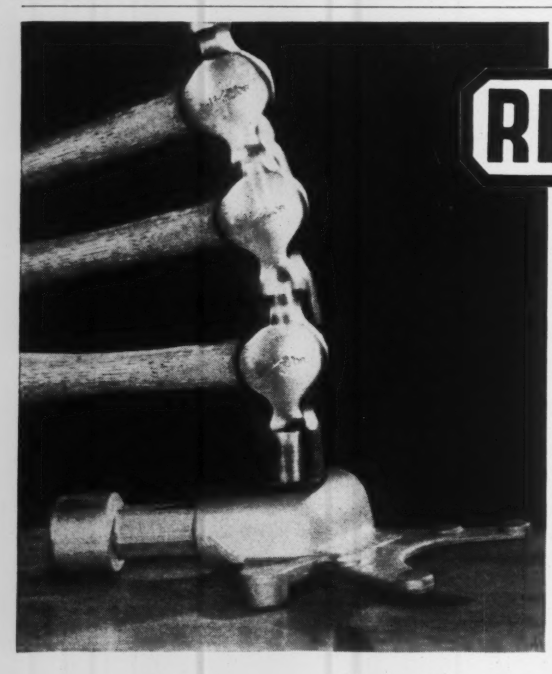
Oblong holes



Ornamental patterns

THE Harrington & King
PERFORATING CO., INC.

Chicago Office and Warehouse • *New York Office and Warehouse*
5671 ½ Fillmore Street 112 Liberty Street, Dept. S
Chicago 44, Illinois New York, New York



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Toughness to shock and stress is just one of the many features found in Ritco Forgings. While their dense, fibrous structure and controlled grain flow assure maximum impact resistance and fatigue strength, their smooth, highly accurate surfaces speed up assembly time, save hours of time and trouble. Made to close tolerance specifications, these finer forgings enable you to hold machining to a minimum . . . keep production costs down.

Plan to write Ritco into your product specifications the next time you need forgings. Made in a wide range of metals and alloys, and in many designs.

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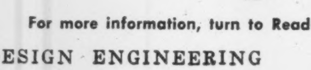
Ritco also offers complete machining facilities and makes Special Fasteners and Upsets of ferrous and non-ferrous metals. Send us your requirements.



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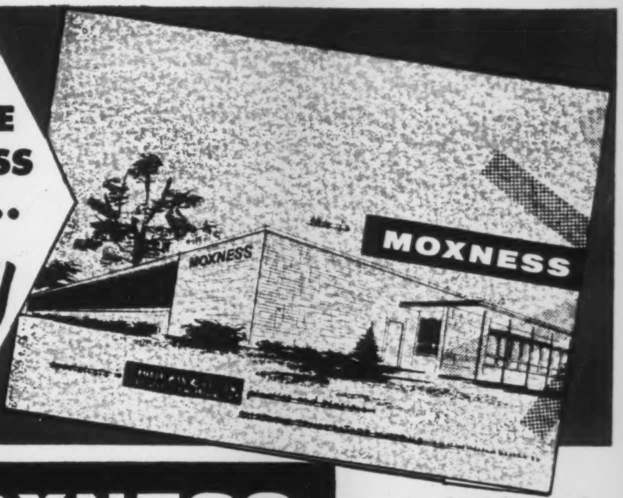

MOXNESS *specialists in*

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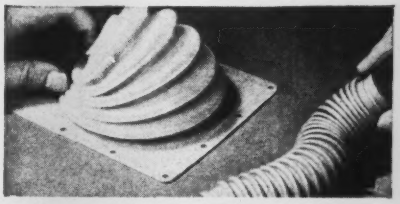
Extreme Temperature Materials *

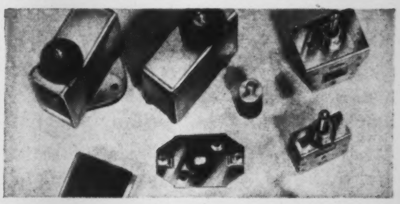
***MOLDED**

Complete, modern, mass-production facilities . . . in the hands of experienced operators who *know* Silicone and Fluorocarbon rubber fabrication . . . plus continuing quality-control production checks . . . all add up to the high standard of quality upon which Moxness stakes its reputation.



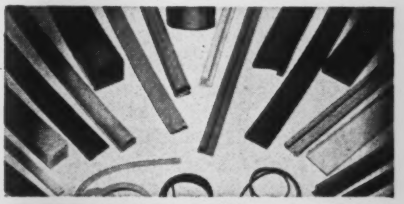
***BONDED**

These "samples" will show you why Moxness is fast becoming recognized as an authority in this specialized field of bonding rubber to many types of metals. The new Moxness plant provides ample facilities for rubber-to-metal bonding to meet exacting specifications and production requirements. Inserts may be furnished by the customer or produced in our plant.



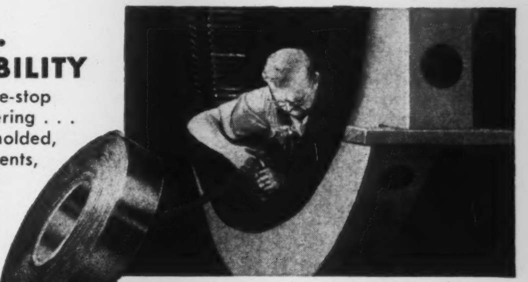
***EXTRUDED**

Large, small, simple or complex . . . here are samples of the wide range of quality extrusions you can expect from Moxness. And, special equipment and an exclusive process developed by Moxness for the precision production of extruded parts is the reason why you will pay less for quality extrusions from Moxness.



**ONE SOURCE...
ONE RESPONSIBILITY**

Moxness offers complete one-stop service . . . Product Engineering . . . Tooling . . . Production. In molded, bonded or extruded components, or in the New TRIANGULAR MOX-TAPE with the Color-Guide Line that cuts taping time by 50-60%. Write for the Moxness Story today!



MOXNESS

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1965 Indiana Street • Racine, Wisconsin
Subsidiary of NATIONAL RIVET and MFG. CO.

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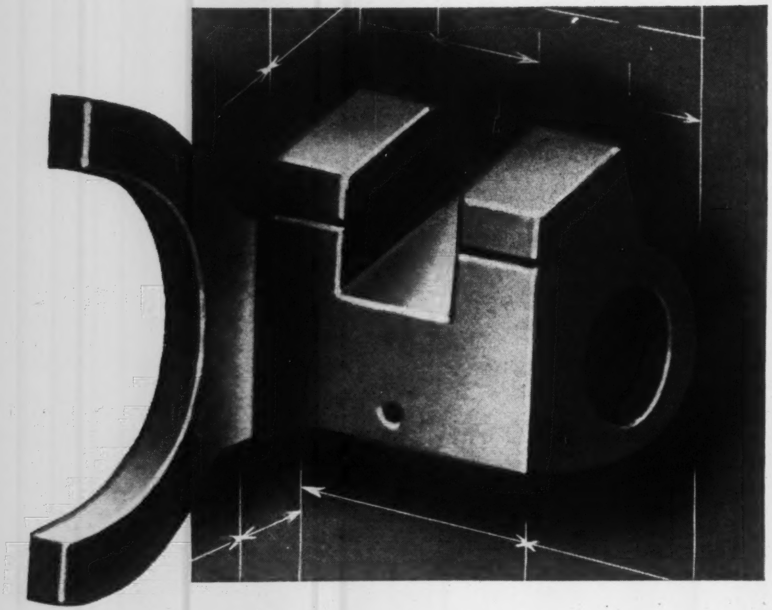

this new part brings outstanding cost reductions...

The photograph is of a shifter fork used in the transmission of a very popular garden tractor in volume production.

Clearly evident is the economy that can be achieved by powder metallurgy over other previously used methods. The elimination of practically all machine work effects striking cost reduction.

Made of pure powdered iron, infiltrated with copper to give added strength and ductility, this part is intended to meet the higher physical properties of wrought metals.

The user of this part naturally presented his problem to Bunting first.

For the unusual, as well as the usual, in bearings, bushings, bars and special parts of cast bronze, sintered metals, or Alcoa aluminum, see Bunting first.

BUNTING SALES ENGINEERS in the field and a fully staffed Product Engineering Department are at your command without cost or obligation for research or aiding in specification of bearings or parts made of cast bronze or sintered metals for special or unusual applications.

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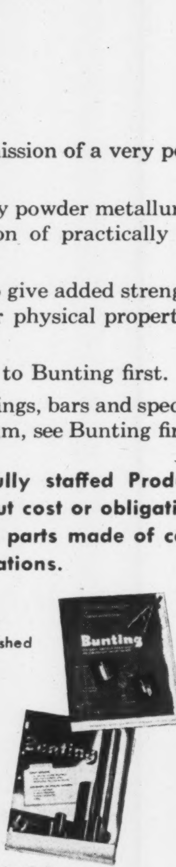

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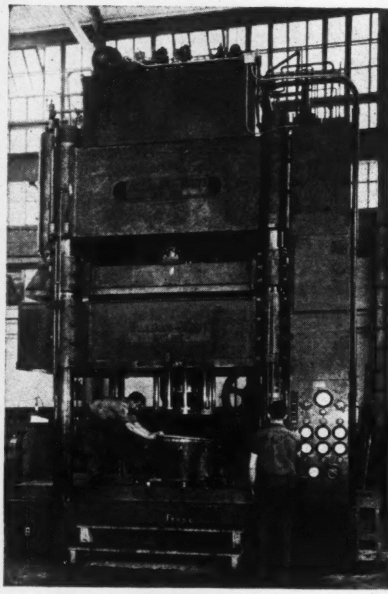

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Giant presses for extremely deep and complex draws in stainless. . . . Automatic heli-arc and manual weldments of superb strength and quality. . . . Extensive machining and polishing facilities. . . . And a large plant so versatile that we welcome one or a million pieces.

But more than that A-P-C engineers offer a KNOW-HOW in stainless steel that is virtually unique . . . gained over wide experiences in stainless steel since 1929.

For quotations, counsel or engineering call in the man from A-P-C.

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STEEL TUBING TIPS:

HOW TO SAVE MONEY WITH TUBING CUSTOM-MADE TO YOUR SPECIFICATIONS!

Millions of feet of GM Steel Tubing have been manufactured at Rochester Products. Modern up-to-date mass-production facilities and procedures assure the most efficient and economical results from your tubing dollar.

Combine the economy of steel with extensive plant facilities, advanced forming equipment and exclusive testing procedures

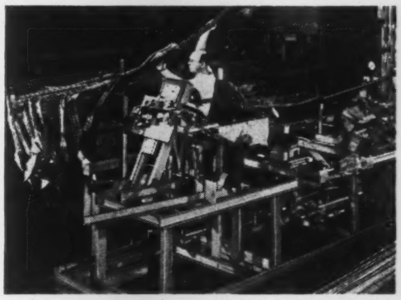
Select a plant with ample space and facilities for initial savings! Extensive plant facilities at Rochester Products are available to produce GM Steel Tubing tailored to your exact specifications in any quantity, any shape or form. Mass-production schedules can be established quickly, using existing equipment, at a substantial saving in time and money.

Ask Tubing Engineer to help cut costs at the planning stage. A GM Steel Tubing Engineer can recommend the best and most economical means of satisfying your specifications on existing high-production manufacturing equipment. His knowledge of industry developments can help make additional savings in tubular components and still retain maximum efficiency.

Enjoy the advantage of advanced forming equipment for further savings. Hydraulic forming fixtures rapidly shape GM Steel Tubing to cut production time and costs. And further fabrication for secondary bends, scoring of tubing break-off, swaging, flaring or bending is also available on automatic equipment.

Benefit from quality controls that eliminate costly warranty losses. All bulk coils of GM Steel Tubing are high-pressure tested and cleaned to a degree many times beyond specifications.

Call your GM Steel Tubing Sales Engineer or write to: Tubing Sales Manager, Rochester Products Division of General Motors, Rochester, New York.



Hydraulic forming fixtures like these at Rochester Products can be adapted to handle your requirements at minimum tooling costs, and help speed production of top-quality tubing components.

Exclusive testing assures greater quality. Solvent is introduced under pressure to all GM Steel Tubing, checking structural strength and giving you the cleanest tubing you can buy.

GM STEEL TUBING by ROCHESTER PRODUCTS

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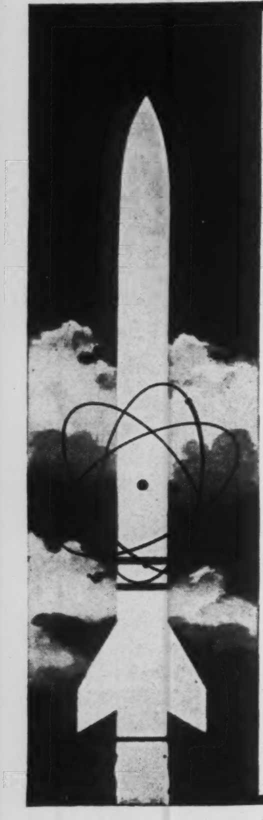

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in the fields of Missiles and Aircraft Electronics, Nuclear Energy

MAGNESIUM-THORIUM This lightweight material has creep resistance and good yield strength at elevated temperatures. B&P produces rolled HK-31 sheet and specializes in HK-31 assemblies for missile and electronic applications.

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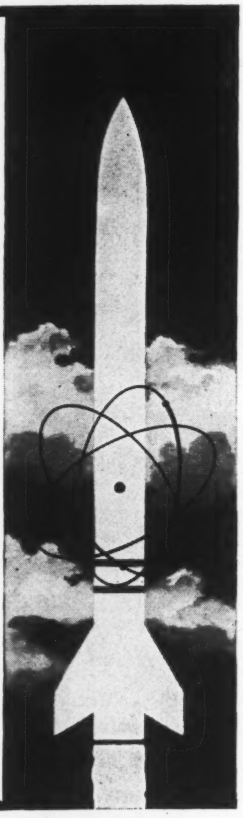

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- **laminating**
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- **bonding**
- **wrapping**

When quality and speed of delivery are essential Dumont Corporation is ready to serve you

- Coordinated machining of composite assemblies

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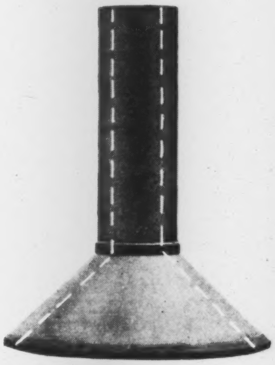
FLIGHT FORGINGS

BY CAMERON

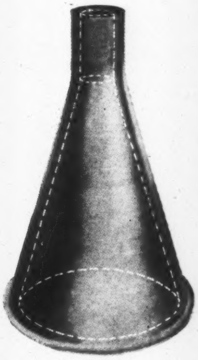
WHEN DEMANDS ARE CRITICAL

The Cameron split-die forging process has created a new concept in forged components that fly. Parts which must handle new extremes in temperature and mechanical stress are now in routine production at Cameron. As an added benefit interesting economies result from savings in the critical materials, often in short supply, which are specified for these important parts. Our facilities are complete through every production phase. We melt many of our own special alloys, bloom, forge, heat-treat, and perform machining operations when required. Each of the shapes below was a problem when presented to our Special Products Division. They are now current production items, adding to our ever-increasing list of extreme service solutions.

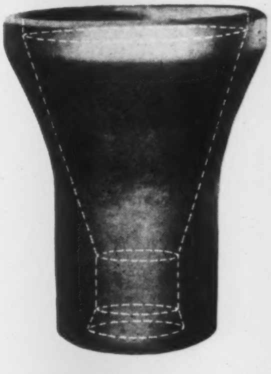
Forging of a Refractory Throat for Polaris Missile
Material: Tantalum 90%
Tungsten 10%
Outside Diameter of Large End: 6.25″
Height: 4″
Outside Diameter of Small End: 5.25″
Weight: 42.25 lbs.



Forging of Turbine Rotor Stub Shaft for Nuclear Jet Engine
Material: A-286 Steel
Outside Diameter of Cone End: 33.687″
Outside Diameter of Shaft: 10.375″
Height: 44.875″
Weight: 1150 lbs.



Forging of a J-93 Front Turbine Shaft for Aircraft Gas Turbine Engine
Material: Waspalloy
Diameter of Conical End: 23.38″
Diameter of Hub End: 6.50″
Length: 27.68″
Weight: 430 lbs.



Forging of a Liner—Exit Cone Missile
Material: Unalloyed Arc Cast Molybdenum
Diameter of Large Conical End: 10.50″
Height: 12.89″
Diameter of Small Conical End: 6.75″
Weight: 104.5 lbs.

If your forging demands are critical, write, call, or come by —

Cameron
IRON WORKS, INC.
SPECIAL PRODUCTS DIVISION
P. O. Box 1212, Houston, Texas

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for extruded aluminum

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There's a World of Difference in Jarl Service, Quality and Engineering Assistance

The Jarl salesman is an engineer—able to understand your design problems... ready to answer your questions knowingly... qualified to make on-the-spot decisions. Before your extruded part or product is put in production, every man on the design team is thoroughly indoctrinated with all pertinent facts covering your requirements.

When Jarl Design Engineering takes over your design problems, you may be sure there will be no costly mistakes later on. Jarl Design Engineering takes out the bugs before the die is cut. You are surer and safer when you team up with Jarl.

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Write for catalog or send sketches or rough dimensional drawings for assistance on your design.

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BOSSERT works wonders with metals!

BOSSERT produces these complex stampings and assemblies...at less cost

You can design with complete freedom of imagination when you plan to use metal stampings for parts or complete assemblies. Intricate shapes can be formed to exact dimensional accuracy in any metal or alloy — often eliminating several separate production operations!

Practical re-design ideas!

Send us your blueprints for evaluation by our engineering department. Parts that are now being cast or forged can often be produced in a single stamping at substantial savings!

Samples of current production

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Write for Bulletin B-2. It describes Bossert's complete facilities for producing metal stampings.

ROCKWELL R STANDARD ®

ROCKWELL-STANDARD CORPORATION
STAMPING DIVISION
1010 OSWEGO STREET UTICA, NEW YORK

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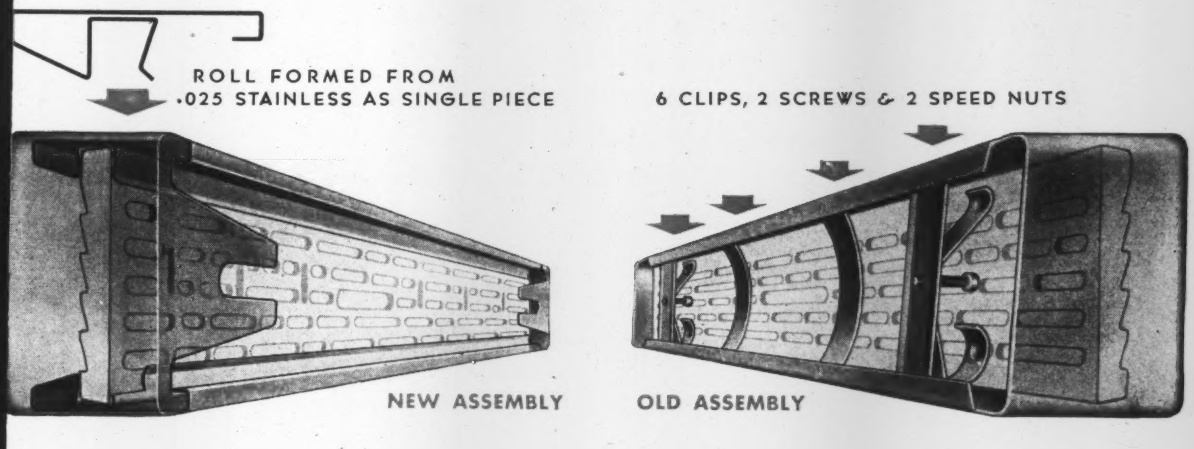
how one Roll Formed shape *eliminated* *six clips* and simplified an assembly


ROLL FORMED FROM
.025 STAINLESS AS SINGLE PIECE
6 CLIPS, 2 SCREWS & 2 SPEED NUTS
NEW ASSEMBLY
OLD ASSEMBLY

IN DESIGN

An expensive stamping and six clips went into this assembly. The stamping had a bad finish and cracked. Now it's Roll Formed from stainless. The finish is bright, shining and can't stain in use. Cracks are eliminated.

IN PRODUCTION

With the stamping the customer inserted a plastic strip and then welded the clips to retain the strip. Screws were positioned manually. Stampings were not uniform. Plastic breakage was high. The new Roll Formed section eliminates the welding operation, guarantees close tolerances, eliminates plastic breakage and cuts assembly time. Screws are not needed.

IN PURCHASING

Rejects were high. Components were hard to get and stampings came from separate suppliers. Deliveries were off-schedule. Now—Roll Formed sections come from one source and are delivered weekly to an open order. Stainless sections are interwoven with paper to protect finishes. Rejects have been eliminated.

CAN TECHNIQUES LIKE THESE HELP YOU?

Probably yes. The Roll Formed man can tell you. He'll go over your prints . . . work out an applicable section . . . plan deliveries with you. Meanwhile, you'll want Roll Formed Bulletin 1017A. It shows how Roll Formed techniques give greater design freedom, increase production and help eliminate purchasing headaches. Get Bulletin 1017A today.

METALS AND TECHNIQUES

Your sections can be produced in: carbon, galvanized and stainless steel; aluminum, copper, zinc and clad metals. Tubing, shapes, channels and angles can be punched, notched, pierced, cut to length and delivered free of burrs to match your production schedule.

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ROLL FORMED PRODUCTS
COMPANY

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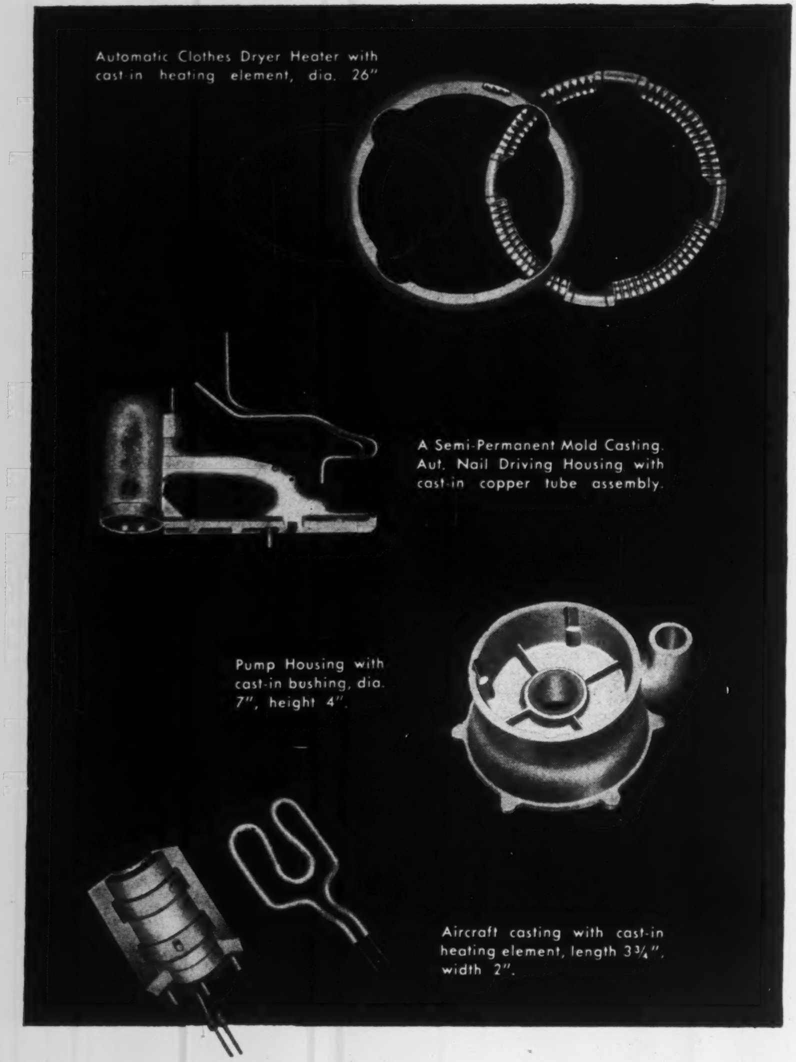

Automatic Clothes Dryer Heater with cast-in heating element, dia. 26"

A Semi-Permanent Mold Casting. Aut. Nail Driving Housing with cast-in copper tube assembly.

Pump Housing with cast-in bushing, dia. 7", height 4".

Aircraft casting with cast-in heating element, length 3¾", width 2".

COMBINATION PERFORMANCES "HARNESSED" WITH ALUMINUM PERMANENT MOLD casting

Your product design requirements may dictate a light weight, rust-proof casting, tailored to perform with a heating element, bushing or insert. ALUMINUM PERMANENT MOLD casting is the answer, as it is superior to other casting methods for holding and positioning metals selected for integral performances.

Shown here are examples of ALUMINUM PERMANENT MOLD CASTINGS already in use. All requiring the physical advantages of aluminum with bearing metals to resist frictional wear, and conductive metals for varied wattage loads. At EXALCO these are common requirements and create no production challenge to our skilled permanent mold casting engineers.

Your "finished product appearance" may be of primary importance. Our DURAGLAZE was developed by us to provide a finish that cannot crack or chip. It is mechanically applied to any flat or contour surface and assures greater durability than chemical and electrochemical finishes.

Feel free to write us for production procedure and estimates of aluminum castings with or without cast-in features.

Exalco MANUFACTURING CO.
ALUMINUM IN PERMANENT MOLD AND SAND
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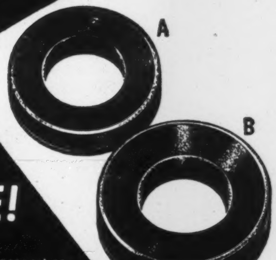
*** KARAK TWINS?**

...NOT ON YOUR LIFE!



Between two shaft seals alone KARAK properties yielded these widely divergent characteristics

Seal Requirements	A	B
Mating surface	Hastalloy C	Stainless Steel
Carbon surface	Hard Polished	Low Friction Film
Pressure at seal	75 PSI	15 PSI
Speed at seal face	5,400 RPM	4,500 RPM
Material under control	HF	Ethylene Glycol
Indicated life of seal	1,200 HRS	1,000 HRS
KARAK specification	A	B

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Make significant reductions in waste, scrap, and time-consuming production operations and, at the same time, improve the quality, uniformity, accuracy and versatility of your machine parts and bearings.

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Get the MD Representative into your production planning! He is familiar with the multitude of different applications of metal powders and will be glad to supply you with a list of qualified fabricators.

METAL POWDERS DIVISION
METALS DISINTEGRATING COMPANY, INC.
GENERAL OFFICES: Dept. X, Elizabeth B, N.J.

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a material answer may be found in molded carbon

SUPERIOR

For example: pump vanes successfully perform when made of carbon

More and more, molded carbon graphite is filling roles heretofore played by other materials. Aside from possible cost reduction, advantages found in this non-metallic are: low noise level, self-lubrication, low coefficient of expansion, chemical inertness. Carbon has other important qualities usually associated with metals, too, such as impact and shear strength, dimensional accuracy, hardness, resistance to abrasion, and can be made non-porous.

Submit your next new material selection problem to Superior for consideration. Or, if you are already using non-metallics, get a price from Superior. Present products of other materials can many times be converted to carbon at a surprisingly low cost per piece. Send in specifications for quotation.

For more detailed information, get Superior's latest data sheet showing properties.

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9115 GEORGE AVENUE • CLEVELAND 5, OHIO

BRUSHES • CONTACTS • SLIP RING ASSEMBLIES
POWDER METAL PARTS • MECHANICAL CARBONS

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You get the combined experience behind these 4 emblems . . . .

This Dollin emblem on your die-castings assures maximum quality and economy, resulting from Dollin's advanced equipment, methods and experienced craftsmen.

Dollin is a supporting member of the American Die-Casting Institute which sponsors research to improve methods, raise standards and broaden applications of die-castings.

Dollin is a licensee of the Certified Zinc Alloy Plan, which assures conformity with industry standards of chemical control and metal purity through independent checking.

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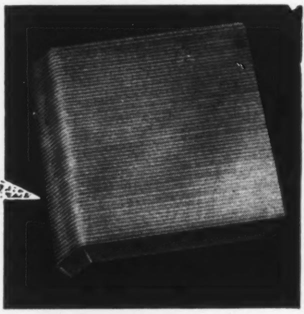

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Kovar Clad Copper	Hard-glass sealing material for lead-in wires for hermetically sealed electrical and electronic products.	Coeff. of exp. 60 x 10^{-7} in./in./°C
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Kulgrid® 64 Nickel Clad Copper	High-temperature conductor extensively used for aircraft spark plug electrodes.	
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Kulgrid® 28 Nickel Clad Copper	**Resistivity**—13.85 ohms/cir. mil ft. @ 68°F	**Operating range**—up to 1000°F
Inconel Clad Copper	**Resistivity**—14.6 ohms/cir. mil ft. @ 68°F	**Operating range**—up to 1100°F
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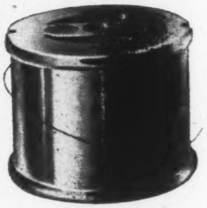

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Sintering Conditions	Copper Content	Sintered Density	Dimensional Change From Tool Size	Tensile Strength
	%	GRM/cc	%/ inch	p.s.i.
TEMP: 2050°F TIME: 45 Mins. ATMOS: Hydrogen	0	5.8	—0.25	18000
	3	5.8	—0.10	27000
	5	5.8	+0.20	36000
	7	5.8	+0.30	40000
	10	5.8	—0.01	42000

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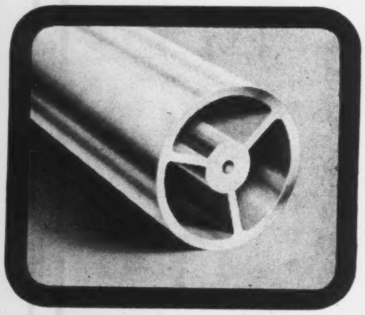

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MML	Heat-treated, molybdenum alloyed manganese steel . . . for castings requiring improved weldability, for extremely heavy metal sections, and castings exposed to excessive heating environments.	tensile strength .... 120,000 psi yield strength .... 52,000 psi elongation .... 50% reduction of area 40%
MMH	Heat-treated, molybdenum alloyed manganese steel . . . for use in castings requiring optimum mechanical properties and wear resistance. Provides improved stiffness and resistance to peening and flow.	tensile strength .... 120,000 psi yield strength .... 65,000 psi elongation .... 20% reduction of area 18%
CML	Heat-treated, air-hardening chrome-moly steel . . . for casting applications involving scouring or grinding wear. Suitable for more complex casting designs.	tensile strength .... 155,000 psi yield strength .... 130,000 psi elongation .... 10% reduction of area .... 15% hardness .... 275-375 BHN
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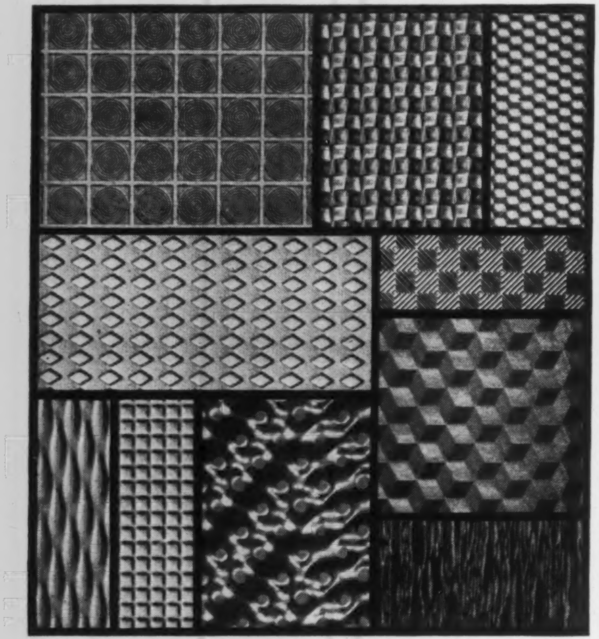

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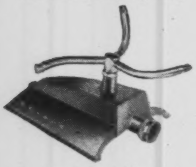
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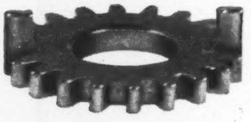
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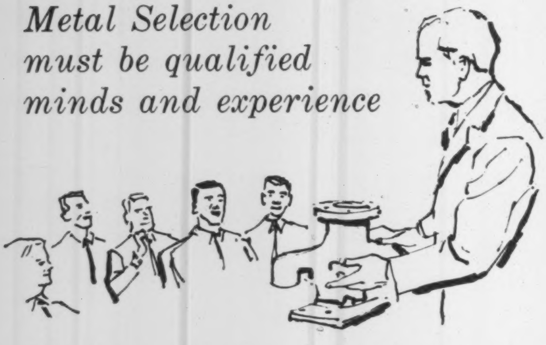

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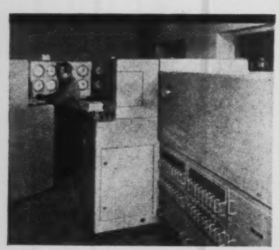

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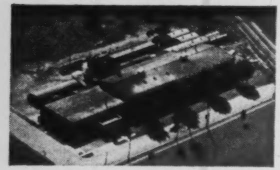

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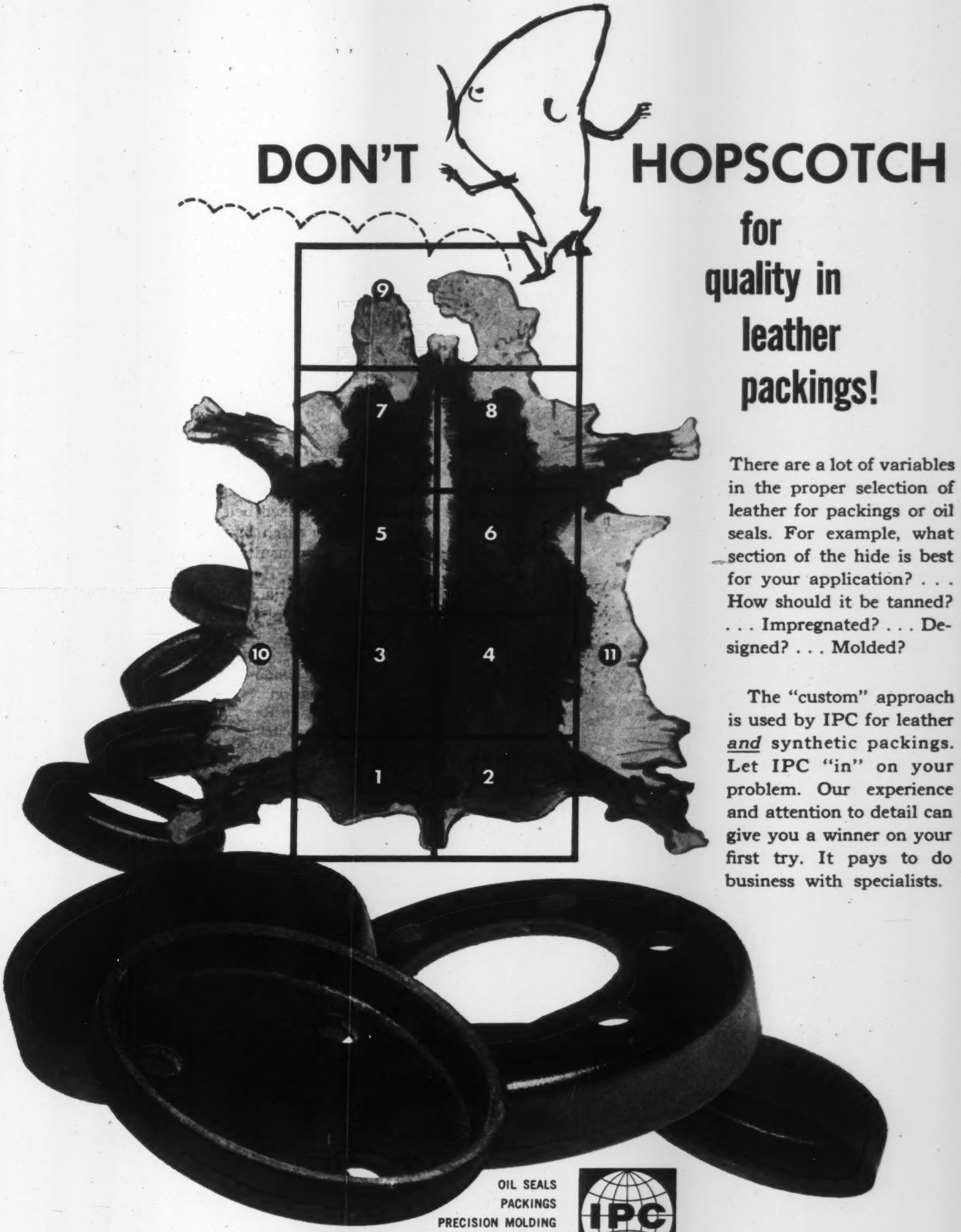

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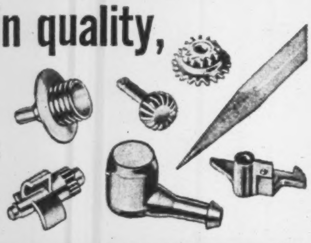

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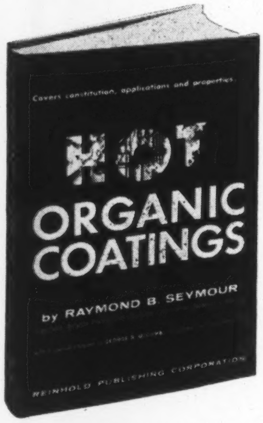
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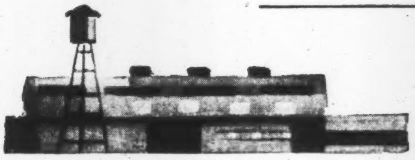

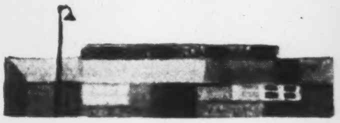

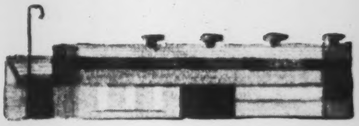

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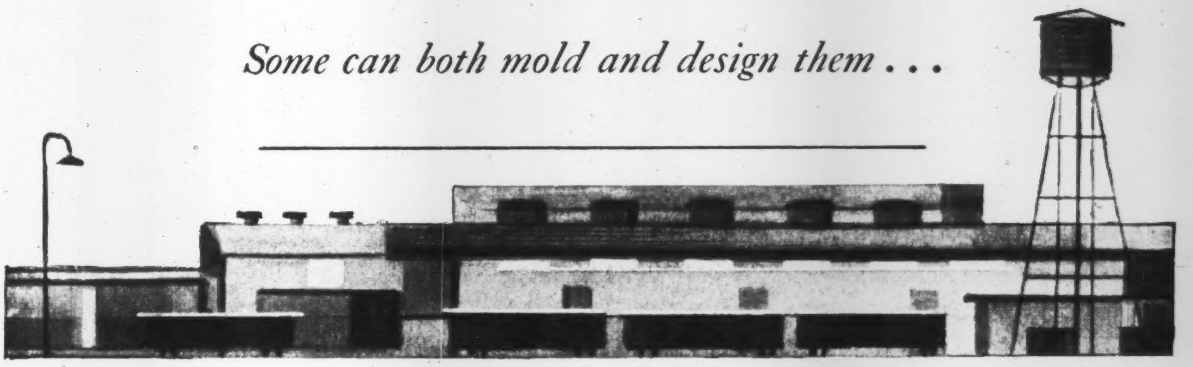

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Fabricated Alloy Div., 4 pp, illus., No. 561-R. Fabrication of stainless steel tanks, heat exchangers and condensers. **314**

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Steel Tubing. General Motors Corp., Rochester Products Div., 12 pp, illus., No. 271. Typical applications of GM tubing made in both single and double walls of steel. **316**

Metal Powder Parts. Supermet Div., Globe Industries, Inc., 8 pp, illus. Design information on Supermet metal powder parts. **317**

Rubber Parts. Goshen Rubber Co., Inc., 8 pp, illus. Describes facilities for producing custom-made parts, seals and components of natural, synthetic and silicone rubber compounds. **318**

Steel Fabrication. Goslin-Birmingham Mfg. Co., 8 pp, illus. Shows company facilities for custom fabricating of such steel process equipment as evaporators, vacuum pans, dryers and heat exchangers. **319**

Small Plastics Parts. Gries Reproducer Corp., 4 pp, illus. Describes and illustrates specialized injection molding of tiny thermoplastic parts. **320**

Copper and Brass Tubing. H & H Tube & Mfg. Co. Describes a complete line of copper and brass tubing. **321**

Fiberglass Structures, Nonferrous Castings. Hampden Brass & Aluminum Co., 6 pp, illus. Facilities for producing fiberglass structures, aluminum and zinc die castings, aluminum permanent mold castings, and aluminum, brass, bronze and monel sand castings. **322**

Perforated Metal Sheets. Harrington & King Perforating Co., Inc., 6 pp, illus. Sizes, gages and materials of perforated metal sheets carried in stock. **323**

Cold Headed Parts. John Hassall, Inc., 12 pp, illus. "What the Designer Should Know about Cold Heading" is the title of an article that outlines the use of cold heading for mass-producing small machine parts and special fasteners. **324**

Honeycomb Sandwich Design. Hexcel Products Inc., 47 pp, illus., No. E. Discusses the primary functions of individual parts in a honeycomb sandwich, the types of stresses involved, design formulas for various loading conditions, effects of change of environment, and selection of sandwich materials. **325**

Beryllium Copper Parts. Instrument Specialties Co., Inc., 20 pp, illus., No. 10. Design information, properties and uses of beryllium copper springs and screw machine products. **326**

Aluminum Extrusions. Jarl Extrusions, Inc. Information on producing and anodizing aluminum extrusions. **327**

Extruded Aluminum Pipe. Kaiser Aluminum & Chemical Sales, Inc., 6 pp, No. NR-28. Sizes and advantages of seamless aluminum pipe for use in cryogenic, pharmaceutical and industrial chemical processes. Information on resistance of aluminum to various chemicals. **328**

Steel Wire. Keystone Steel & Wire Co., 12 pp, illus., No. 1a Ke. Illustrates various kinds of steel wire and discusses cold heading. **329**

Sheet, Plate Fabrications. Kirk & Blum Mfg. Co., 40 pp, illus. Information on more than 100 different sheet and plate fabrications including stampings, enclosures and tanks. **330**

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Alloy Castings. Meehanite Metal Corp., 4 pp, illus., No. 7. Shows the use of various heat, wear and corrosion resistant steel castings as dies and machinery parts. **336**

Die Castings. Monarch Aluminum Mfg. Co., illus. Information on the mass production of permanent mold castings and aluminum and zinc die castings. **337**

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Silicone, Fluorocarbon Rubber Parts. Moxness Products, Inc., 4 pp, illus. Shows facilities for producing fluorocarbon and silicone rubber products. **339**

Impact Extrusions. Mueller Brass Co. Mechanical properties and dimensional tolerances of round, rectangular and square impact extrusions. **340**

Die Castings. Doehler-Jarvis, Div. of National Lead Co., 6 pp, illus. Advantages and limitations of zinc, aluminum and magnesium die casting alloys. Case histories on the use of die castings in chain saws and movie cameras. **341**

Fabricated Nylon Parts. National Vulcanized Fibre Co., 6 pp, illus. Mechanical, thermal and electrical properties of nylon extruded rod and fabricated parts. **342**

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Expanded Metal. Penn Metal Co., Inc., 4 pp, illus., No. 510-EM. Sizes, dimensions, weights and uses of small, medium and large-mesh expanded metal. **347**

Perforated Rubber, Fabrics. Perforating Industries, Inc., 16 pp, illus., No. 57. Information on perforating, slitting and blanking of coated fabrics, plastics, rubber, hides, felt, paper, fabrics, foam rubber and imitation leather. **348**

Steel Tubing. Pittsburgh Tube Co., 60 pp, illus. Manufacture, uses, machinability, tolerances and mechanical properties of cold drawn welded mechanical steel tubing. **349**

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Zinc Die Castings. St. Joseph Lead Co., 22 pp, illus. Discusses zinc die casting alloys and commercial finishes for zinc die castings. **362**

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Copper, Brass Tubing. Scovill Mfg. Co., Mill Products Div., 20 pp, illus. Specifications and uses for copper and brass tubing. Shows facilities for drawing, annealing, pickling and inspecting tubing. **364**

Iron Castings. Sorbo-Mat Process Engineers, 18 pp, illus. Physical and mechanical properties, composition and uses of "controlled specification" cast irons. **365**

Graphite Anodes. Stackpole Carbon Co., 18 pp, illus. Physical properties, and underground and seawater applications of graphite anodes. **366**

Precision Rubber Parts. Stalwart Rubber Co., 16 pp, illus. Information on type of rubber stocks from which company fabricates precision parts. **367**

Small Plastics Parts. Standard Plastics Co., Inc., 8 pp, illus. Describes a custom service for molding thermoplastic and thermosetting resins into small plastics parts, such as lenses, bearings, and jewelry. **368**

Reinforced Plastics Products. Structural Fibers, Inc., 2 pp, illus. Information on reinforced plastics tanks, battery cases and other products made by internal pressure, matched die and premix molding techniques. **369**

Metal Powder Parts. Superior Carbon Products, Inc., 4 pp, illus., No. M-2057. Tensile strength, density, elongation and porosity of tin, copper, brass, iron, steel and iron-copper metal powder parts. **370**

Small Diameter Tubing. Superior Tube Co., 12 pp, No. 41. Characteristics and uses of 63 standard and 26 special materials cold drawn by the company into small tubing. **371**

Nickel, Steel and Composite Wire. Sylvania Electric Products Inc., Parts Div., 6 pp. Chemical composition, and physical, mechanical and electrical properties of nickel, nickel alloy, stainless steel, plated and clad wire. **372**

Malleable Iron Castings. Texas Foundries, Inc., 20 pp, illus. Describes foundry facilities and provides case histories on the use of malleable iron. **373**

Clad Metals. Texas Instruments, Inc., Metals & Controls Div., 12 pp, illus., No. GP-1. Design information, properties and uses of precious and clad metals, thermostat metals and solid and clad precious metals. **374**

Wire Forms, Assemblies. E. H. Titchener & Co., 24 pp, illus. Information on the use and advantages of ferrous and nonferrous wire forms, wire assemblies and wire-strip assemblies. **375**

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Chemical Milling of Steel. United States Chemical Milling Corp., 2 pp, No. 8. Information on the chemical milling of carbon and stainless steel. Discusses the effect of chemical milling on the physical properties, surface finishes and tolerances of steel. **377**

Fabricating Stainless Steel. United States Steel Corp., 132 pp, illus. Data on welding, riveting, soldering, machining, forming, annealing and surface finishing austenitic, ferritic and martensitic stainless steels. **378**

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Steel Products. Wheeling Steel Corp., 12 pp, illus. Shows facilities for producing pressed and drawn steel stampings, hot rolled electrical sheets, galvanized sheets, electrolytic tinplate and steel pipe. **384**

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High Strength Adhesive. Eastman Chemical Products, Inc., 12 pp, illus., No. R-103. Application data, physical properties, heat and chemical resistance, and tensile properties of bonds made with a high strength adhesive called 910. 406

Silver Brazing Alloys. American Platinum Silver Div., Engelhard Industries, Inc., 4 pp, illus. Chemical composition, melting point, uses and brazing instructions for eight silver brazing alloys. 407

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Cold Headed Parts. John Hassall, Inc., 4 pp, illus. Outlines cost savings achieved by cold heading spacers and certain threaded fasteners. 414

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Self-Locking Nuts. Mac Lean-Fogg Nut Co., 8 pp, illus., No. 7-Ma. Properties, uses and dimensions of self-locking nuts. 418

Adhesives. Minnesota Mining & Mfg. Co., Adhesives, Coatings and Sealers Div., 12 pp, illus. Design concepts, uses and characteristics of natural and synthetic rubber, and plastics adhesives. Information also on coatings and sealers. 419

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Adhesives. Rubber & Asbestos Corp., 16 pp, illus., No. 135. Discusses various types of adhesives and adhesive bonding techniques used in the construction of sandwich panels. 424

Lock Screw Fasteners. Russell, Burdsall & Ward Bolt & Nut Co., 3 pp, illus. Advantages and dimensions of spinlock screws. 425

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Fasteners. Tinnerman Products, Inc., 16 pp, illus., No. 350-1. Information on self-locking fasteners for threaded and non-threaded parts. 430

Cold Headed Fasteners. Progressive Mfg. Co., Div. of Torrington Co., 16 pp. How cold heading improves design and adds strength to various types of fasteners. 431

Lockbolts. Townsend Co., 8 pp, illus. Installation data, dimensions, uses, features and design data on lockbolts. 432

Methods for Welding Metals. Linde Co., Div. of Union Carbide Corp., 36 pp, illus. Discusses various welding techniques for joining ferrous and nonferrous metal parts such as tanks, railroad cars, condensers and bulldozers. 433

Pop Rivets. United Shoe Machinery Corp., Pop Rivet Div., 4 pp, illus. Dimensional data and ordering information on "Pop" rivets. 434

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Joining and Fastening of Materials

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Joining and Fastening of Materials

Joinability of Materials[a]

Material ↓	Arc Welding	Oxyacetylene Welding	Resistance Welding	Brazing
Cast Iron	Common by shielded metal arc where ductile weld not required	Rec with cast iron rods; braze welding if no corr or thermal stress	Seldom; if used, flash welding preferred	Dfclt; easiest for quality-controlled and Ni-cont types
Carbon and Low Alloy Steels	Rec for low carbon and low alloy, common for medium, dfclt for high; all processes	Rec with rods of same comp for low carbon, low alloy; incr C makes more dfclt	Rec for low carbon and low alloy; flash and upset used as C incr dfclt	Rec for low, medium carbon; dfclt for high; seldom for heat treated alloy steels
Stainless Steel	Rec for 200 and 300 series, common for 400 series; all processes	Common for thin gages, dfclt for thicker	Rec for 300 series; 400 series susceptible to hardening	Rec with silver brazing alloys
Aluminum, Magnesium	Common by inert gas; Al slightly easier than Mg	Common for Al <1 in., Mg & M1 alloy; others dfclt	Common; Mg more dfclt, though spot welding used	Common for Al alloys and Mg alloy M1
Copper and its Alloys	Common by inert gas; electrolytic Cu joints not high str	Common for most; seldom for phosphor and aluminum bronzes	Common by upset or modified flash upset methods	Rec for Cu and high Cu brasses; ease with bronzes varies widely
Nickel and its Alloys	Rec for Ni, monel, Inconel; all processes	Common for Ni, monel, Inconel	Rec for most; Inconel X dfclt	Rec
Titanium	Common by inert gas	No	Common by spot and flash welding	Difficult
Lead, Zinc	Common for lead by inert gas; no for zinc	Common	Dfclt for zinc, but spot and seam used; no for lead	No
Thermoplastics	(Heated tool welding.) Rec for acrylic sheet, common for most TP sheet	(Hot gas welding.) Rec for polyethylene, PVC; common for other TP's	(Induction welding.) Common for polyethylene, acrylic; metal insert remains integral	No
Thermosets	No	No	No	No
Elastomers	No	No	No	No
Ceramics	No	Seldom	No	No
Glass	Seldom	(Blow torch.) Common	No	No
Wood	No	No	No	No
Leather	No	No	No	No
Fabric	No	No	No	No
Dissimilar Metals	Dfclt; used where melting points are within about 50 °F; galvanic action danger	Dfclt; used when melting points are within about 50° F; galvanic action danger	Dfclt; special procedures because of different thermal prop.; galvanic action danger	Ranges from dfclt to common depending on deg of dissimilarity
Metals to Nonmetallics	No	No	No	No
Dissimilar Nonmetallics	(Hot gas welding.) Dfclt; used on TP's of same basic type	(Hot gas welding.) Dfclt; used on TP's of same basic type	No	No
Dissimilar Thicknesses	Common	Common	Common	Rec

[a] Abbreviations used in the table: TP = Thermoplastic. TS = Thermosetting. Elast = Elastomeric. Rec = Recommended; easily accomplished with excellent results. Common = Commonly and widely used, though some care may be necessary. Dfclt = Difficult; special precautions, equipment, etc., necessary. Seldom = Can be done with more or less difficulty, but not common for one reason or another. No = Not used; impossible or highly specialized case if ever used.

Soldering	Adhesive Bonding (TS, TP, Elast)	Adhesive Bonding (modified compounds)	Threaded Fastening	Riveting and Metal Stitching
Seldom; graphite and high silicon content prevent bonding	Common with TS, seldom with TP	Common with epoxy 100% solids; dfclt with solvent-dispersed phenolic	Common; esp self-tapping, also integrally cast studs, hooks, etc.	Rec with large solid rivets in structural uses
Dfclt for lower carbon; seldom for higher carbon	Common with TS, seldom with TP	Common with epoxy 100% solids in paste form	Rec with all types; most fasteners made of same mtls	Rec with solid rivets for high shear, medium ten str uses
Common for 300 series with high tin solders; dfclt for 400 series	Common with TS, seldom with TP	Common with epoxy 100% solids in paste form	Rec with bolts and nuts, common with others	Common with solid stainless steel rivets for high shear str uses
Seldom; special solders available	Rec with TS, common with others, but no alkaline adh	Rec with all types	Common with self-tapping screws, inserts, others	Common with small solid aluminum rivets, or semi-tubular where low stress
Rec for copper, brass, bronze in that order	Common with TS, seldom with TP, but no natural rubber adh	Common with epoxy 100% solids as paste or film	Common with fasteners available in similar mtls	Common with small solid copper alloy rivets, seldom with semi-tubular
Common with high tin solders or others rel noncorr	Common with TS, seldom with TP	Common with epoxy 100% solids as paste or film	Rec with fasteners available in similar mtls	Common with small solid nickel alloy rivets, seldom with semi-tubular
Seldom	Seldom with TS, no TP	Common with epoxy 100% solids, heat and pressure-cured	Common; some Ti fasteners available	No
Rec with low melting solders	Rec with TS, TP, Elast in that order	Rec with all types	Rec with self-tapping screws, inserts, special fasteners	Rec with semi-tubular or split rivets, seldom with solid
No	Common with Elast for cryst types; solvent selection care nec to avoid crazing	Seldom; phenolic-Buna N most used	Seldom; inserts are used, also special fasteners	Rec with tubular rivets; stitching common (limited thk)
No	Common with TS; solvent selection care nec to avoid crazing	Common with modified epoxies on TP–TS compounds	Common with self-tapping screws, elevator bolts, inserts	Rec with semi-tubular rivets
No	Rec with phenolic, epoxy and neoprene adhesives	Common with epoxy-polysulfide, phenolic-elastomers	Seldom; inserts are used, also special fasteners	Rec with tubular or split rivets; stitching common
No	Rec with epoxy, common with other TS adhesives exc ureas	Rec with vinyl-phenolics, modified epoxies, phenolic-elastomers	Common with nuts, washers and bolts, esp load-indicating types	Seldom; semi-tubular rivets used
No	Rec with TS, common with Elast	Rec with vinyl-phenolics, phenolic-elastomers	Common with plastics fasteners, seldom with elevator bolts	Seldom; TP semi-tubular rivets used
No	Rec; phenolic for soft plywood, melamine-urea for laminations, PVC for furniture	Rec with solvent-dispersed phenolic-elastomers, latex emulsions	Rec with wood and lag screws, self-tapping screws, inserts, dowels, etc.	Common. Semi-tubular rivets for hard woods, tubular rivets for soft
No	Rec with Elast, common with TS	Rec with asphalt and latex emulsions, solvent dispersions	Seldom	Rec with tubular and split rivets, and stitching or stapling
No	Rec with Elast, polyvinyl acetate and cellulosic adh	Rec with asphalt and latex emulsions	Seldom	Rec with split rivets, stitching
Rec except where galvanic corr must be considered	Rec with TS exc solvent-dispersed types	Rec with epoxy 100% solids	Common but galvanic action may be a danger	Common although galvanic action is a danger
No	Rec. TP for shear str; TS Elast for peel str	Rec with solvent-dispersed phenolic-elastomers	Common using self-tapping screws, inserts, special fasteners	Rec with self-tapping screws, inserts, stitching
No	Rec; type varies with porosities being joined	Rec; type varies with porosities being joined	Seldom	Rec with lag screws, stitching, special fasteners
Rec	Rec where load is not peel	Rec with all types	Rec, esp bolts	Rec, esp stitching

Brazing and Soldering Alloys

Classification

Unlike welding filler metals, these alloys melt at lower temperature than the metals being joined —brazing alloys above 800 F, soldering alloys below.

Brazing Alloys. Alloys are classified by chemical composition. The two most common groups are silver alloys and copper and copper alloys. All must melt and flow freely at a lower temperature than the metals being joined, adhere to the surfaces being joined, and not oxidize or volatize too freely.

Brazing fluxes. Choice of the proper brazing flux is extremely important. Fluxes minimize oxidation, dissolve oxides that may have formed, and promote free flowing of the filler metal. A great number of proprietary fluxes are available, each with specific recommendations for use. Most of them can be classified as high temperature (above 1500 F), general-purpose low-temperature, or special purpose.

Soldering alloys. The most widely used soft solders are those composed of tin and lead, with or without other minor alloying elements. Other types include lead-silver, silver-tin-lead, bismuth-tin-lead, indium-bearing and aluminum solders.

Soldering fluxes. The most important factor in producing a sound soldered joint is the proper choice and use of a flux. The many available fluxes can be classified in two groups—corrosive and noncorrosive.

Brazing and Soldering Methods

Similar methods of heating are used for brazing and soldering. However, the furnace and salt dip methods are seldom used for soldering, and the soldering iron is not used for brazing. The most common methods use:

Soldering iron. The "iron" has a copper tip which is generally heated electrically. It is used mostly for electrical connections.

Torch. Oxyacetylene, oxyhydrogen or other gas flame torches are widely used for repair work.

Induction heating. Parts are assembled in a fixture which positions them inside an induction coil. Advantageous for large quantities of small parts.

Electric block. Similar to resistance welding with lower current. Used for small electrical parts.

Salt dip. Brazing alloy is preloaded into the work and parts are dipped into molten salt bath. Advantageous for dissimilar thicknesses and aluminum.

Metal dip. Parts are dipped in bath of molten brazing or soldering alloy. Used for irregular shapes.

Furnace. Brazing alloy is preloaded into work (usually held in jigs) which is then heated to brazing temperature in a controlled atmosphere furnace. Economical for large volumes of work.

Design Factors

Comparisons. Though brazed joints are not as strong as welded, the lower temperatures required are advantageous in that the process is faster, is performed more economically, and results in less distortion. Soldered joints are not recommended where any stress will be applied.

Joint design. Three basic types of joints are used in brazing: butt, scarf and lap. Lap joints are preferred where maximum strength is preferred. Butt joints are not recommended for soldering.

SOLDERING FLUXES

Flux ↓	Characteristics	Uses
Rosin	Noncorrosive, nonconducting, nonhygroscopic	Electrical
Tallow	Very mildly corrosive	Lead, brass, clean copper
Olive Oil or Gallipoli Oil	Very mildly corrosive	Pewter, block tin
Stearic Acid	Mildly corrosive, almost nonconductive	Electrical, lead
Aniline Phosphate or Aniline Chloride	Mildly corrosive, almost nonconductive	Electrical
Lerulinic Acid in Alcohol	Mildly corrosive, almost nonconductive	Tin cans
Lactic Acid, Phthalic Acid and Phosphoric Acid Mixed with Tallow, Resin, etc.	Mildly corrosive, slightly conductive	Electrical
Zinc Chloride	Corrosive	Iron, steel, zinc, copper, brass, bronze; terne and lead plate
Zinc Chloride and Hydrochloric Acid	Corrosive	Stainless steel, nickel, monel
Zinc Chloride and Hydrofluoric Acid	Corrosive	Brasses and bronzes containing aluminum, silicon and manganese
Orthophosphoric Acid	Corrosive	High tensile manganese bronze
Numerous Proprietary Pastes Usually Containing Zinc Chloride	Corrosive	—
Zinc Chloride and Ammonium Chloride	Corrosive	Iron, zinc, copper, brass, bronze
Dilute Hydrochloric Acid	Corrosive	Dirty zinc
Fused Salts of Zinc Chloride and Ammonium Chloride	Corrosive	Dipping method

Definitions

Eutectic. An alloy which has a melting *point* and not a *range*.

Liquidus. The lowest temperature at which the alloy is completely liquid.

Melting range. The range from the liquidus to the solidus temperature.

Solidus. The temperature at which the alloy begins to melt.

TYPICAL SOFT SOLDERS

ASTM Type ↓	Nominal Composition	Solidus, F	Liquidus, F	Spec Grav	Ten Str, 1000 psi	Applications
TIN-LEAD ALLOYS						
70A, 70B	Sn 70, Pb 30, Sb 0.12–0.50	361	378	8.32	6.8	Soldering Zn-coated ferrous metals; coating metals
...	Sn 62, Pb 38	361	361	—	—	General purpose; eutectic alloy
60A, 60B	Sn 60, Pb 40, Sb 0.12–0.50	361	374	8.65	6.4	General purpose, esp where temp needs critical
50A, 50B	Sn 50, Pb 50, Sb 0.12–0.50	361	421	8.85	5.9	General purpose; most commonly used for iron, steel, Cu alloys, Zn. Domestic plumbing
45A, 45B	Sn 45, Pb 55, Sb 0.12–0.50	361	441	8.97	—	Auto radiator cores, roofing seams
40A, 40B	Sn 40, Pb 60, Sb 0.12–0.50	361	460	9.3	5.8	Wiping lead pipes, cable sheaths. Auto radiator cores, galvanized iron and Zn heating units
35A, 35B	Sn 35, Pb 65, Sb 0.25–0.50	361	477	9.5	—	General purpose; wiping solder
30A, 30B	Sn 30, Pb 70, Sb 0.25–0.50	361	491	9.7	5.6	Machine, torch, dip, wiping methods
25A, 25B	Sn 25, Pb 75, Sb 0.25–0.50	361	511	10.00	—	Machine, torch methods
20B	Sn 20, Pb 80, Sb 0.5	361	531	10.20	5.3	Joining metal parts <¼ in. thk; filling dents or seams in auto bodies; coating metals
15B	Sn 15, Pb 85, Sb 0.50	361	550	10.50	—	Joining, coating; tinning auto bodies
10B	Sn 10, Pb 90, Sb 0.50	361	570	10.80	—	Joining, coating
5A, 5B	Sn 5, Pb 95, Sb 0.12–0.50	518	594	11.30	3.4	Joining and coating, esp at high temp to 250 F
TIN-LEAD-ANTIMONY ALLOYS•						
...	Sn 94, Pb 0.2, Sb 4–6	450	464	—	—	General purpose
40C	Sn 40, Pb 58, Sb 1.8–2.4	365	448	9.23	—	Same as 50A, 50B
35C	Sn 35, Pb 63.2, Sb 1.6–2.0	365	470	9.44	—	General purpose; wiping
30C	Sn 30, Pb 68.4, Sb 1.4–1.8	364	482	9.65	—	Torch, machine methods
25C	Sn 25, Pb 73.7, Sb 1.1–1.5	364	504	9.96	—	Same as above
20C	Sn 20, Pb 79, Sb 0.8–1.2	363	517	10.17	—	Machine soldering and coating; tipping
TIN-LEAD-INDIUM ALLOYS						
...	Sn 37.5, Pb 37.5, In 25.0	274	358	—	—	Where res to strong alk soln needed (high cost)
SILVER-LEAD AND SILVER-CADMIUM ALLOYS						
2.5 S	Sn 0, Pb 97.5, Sb 0.40, Ag 2.3–2.7	579	579	11.35	5.0	Cu, brass and similar metals with torch heating. Suitable for high temp but not for humid environ.
1.55	Sn 1, Pb 97.5, Sb 0.40, Ag 1.3–1.7	588	588	11.28	—	Cu, brass and similar metals with torch heating. Sealing tin cans. High temp use
...	Ag 5, Cd 95	640	750	—	—	High temp use
CADMIUM-ZINC AND LEAD-CADMIUM-ZINC ALLOYS						
...	Pb 90, Cd 8, Zn 2	410	530	—	—	Zn and galvanized parts
...	Cd 82.5, Zn 17.5	508	508	—	—	Zn-base die castings; high temp
LOW MELTING ALLOYS (BISMUTH-CONTAINING)						
...	Bi 56, Pb 22, Sn 22	203	220	—	—	Special uses where low mp needed in soldering or svc
...	Bi 67, Pb 16, Sn 17	203	300	—	—	Same as above
...	Bi 40, Sn 60	281	338	—	—	Same as above
...	Bi 42.5, Pb 32.7, Sn 11.3, Cd 8.5	158	194	—	—	Same as above
...	Bi 58, Sn 42, Zn 4	266	266	—	—	Same as above
ALLOYS FOR SOLDERING ALUMINUM						
...	Sn 55–70, Zn 30–45	630	—	—	—	Range of special alloys for Al; also used on Mg
...	Sn 75, Zn 25	401	500	—	—	Soldering capacitors to Al sheets
ALLOYS FOR SOLDERING MAGNESIUM						
...	Sn 60, Zn 40	630	—	—	—	Magnesium
...	Cd 60, Zn 30, Sn 10	315	—	—	—	General purpose
...	Cd 90, Zn 10	500	—	—	—	Magnesium

• Not recommended for use on galvanized iron, cadmium or zinc parts.

continued on next page

Brazing and Soldering Alloys

BRAZING FILLER METALS

AWS-ASTM Class ↓	Major Composition %	Available Forms	Solidus, F	Liquidus, F	Special Factors
ALUMINUM-SILICON					
BAlSi-1	Si 4.0–6.0, Al bal	Strip, wire, rod	1070	1165	—
BAlSi-2	Si 6.8–8.2, Al bal	Coated sheet	1070	1135	Only as coating on 3003, 5951
BAlSi-3	Si 9.3–10.7, Cu 3.3–4.7, Al bal	Strip, wire, rod	970	1085	—
BAlSi-4	Si 11.0–13.0, Al bal	Wire	1070	1080	Highly corr res
COPPER-PHOSPHORUS					
BCuP-1	P 4.75–5.25, Cu bal	Strip, wire	1305	1650	More ductile than others; less fluid
BCuP-2	P 6.75–7.50, Cu bal	Rod	1305	1485	Very fluid
BCuP-3	P 6.00–6.50, Ag 4.75–5.25, Cu bal	Wire, rod, powder	1195	1500	Very fluid
BCuP-4	P 6.75–7.80, Ag 5.75–6.25, Cu bal	Rod, powder	1185	1380	—
BCuP-5	P 4.75–5.25, Ag 14.50–15.50, Cu bal	Strip, wire, rod, powder	1185	1500	Suitable where close fits cannot be held
SILVER					
BAg-1	Ag 44–46, Cu 14–16, Zn 14–18, Cd 23–25	Strip, wire, rod, powder	1125	1145	Free flowing, narrow melting range
BAg-2	Ag 34–36, Cu 25–27, Zn 19–23, Cd 17–19		1125	1295	Free flowing, broader melting range than above
BAg-3	Ag 49–51, Cu 14.5–16.5, Zn 13.5–17.5, Cd 15–17, Ni 2.5–3.5		1195	1270	Good wetting action on carbide; wide melting range; good corr res
BAg-4	Ag 39–41, Cu 29–31, Zn 26–30, Ni 1.5–2.5		1240	1435	Same as above, but freer flowing
BAg-5	Ag 44–46, Cu 29–31, Zn 23–27		1250	1370	Wets, flows well; malleable, ductile
BAg-6	Ag 49–51, Cu 33–35, Zn 14–18		1270	1425	Same as above; low elec res, high ductility
BAg-7	Ag 55–57, Cu 21–23, Zn 15–19, Sn 4.5–5.5		1145	1205	Less stress corr cracking on stainless, some Ni alloys
BAg-8	Ag 71–73, Cu 27–29		1435	1435	Free flowing except on ferrous metals
BAg-9	Ag 64–66, Cu 19–21, Zn 13–17		1280	1325	—
BAg-10	Ag 69–71, Cu 19–21, Zn 8–12		1335	1390	—
BAg-11	Ag 74–76, Cu 21–23, Zn 2.5–3.5		1365	1450	—
COPPER-GOLD					
BCuAu-1	Au 37.25–37.75, Cu bal	Strip, wire	1775	1815	[f]
BCuAu-2	Au 79.75–80.25, Cu bal	Strip, wire	1620	1630	[f]
COPPER					
BCu	Cu 99.90 min	Strip, wire, rod	1980	1980	Free flowing
COPPER-ZINC					
BCuZn-1	Cu 58.0–62.0, Zn bal	Strip, wire, rod	1650	1660	Free flowing; mod str
BCuZn-2	Cu 57.0 min, Sn 1.0, Zn bal	Strip, wire, rod	1630	1650	Free flowing; higher str than above
BCuZn-3	Cu 56.0 min, Sn 1.10, Mn 1.0, Ni 1.0, Zn bal	Strip, wire, rod	1590	1630	Used for capillary brazing
BCuZn-4	Cu 50.0–55.0, Zn bal	Grain	1570	1595	Low mp; somewhat brittle
BCuZn-5	Cu 50.0–53.0, Sn 3.0–4.5, Zn bal	Grain	1585	1610	Used for capillary brazing
BCuZn-6	Cu 46.0–50.0, Ni 9.0–11.0, Zn bal	Strip, wire, rod	1690	1715	Generally used to make V fillet
BCuZn-7	Cu 46.0–48.0, Ni 10.0–11.0, Ag 0.30–1.0, Zn bal	Strip, wire, rod, powder	1685	1710	High mp; good color match
MAGNESIUM					
BMg	Al 8.3–9.7, Zn 1.7–2.3, Mg bal	Wire, rod	770	1110	Good corr res; high str, ductility
HEAT RESISTING MATERIALS					
BNiCr	Ni 65–75, Cr 13–20, B 2.75–4.75[k]	Strip, wire, powder	1850	1950	Retains prop. to 2000 F
BAgMn	Ag 84–86, Mn 14–16	Strip, wire, rod	1760	1780	Good str at 500–900 F

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[a] Immersion in 10% sulfuric acid restores copper color.

[b] BCuP-1: particularly resistance, and some furnace brazing.

[c] Lap and tee; strong, ductile joint; shear strength 20–30,000 psi.

[d] BAg-7 particularly for furnace brazing.

[e] All ferrous and nonferrous metals except Al, Mg, Ti and other metals melting below 1500 F. BAg-9, 10, 11 are used together for step brazing.

Brazing Methods	Brazing Temp Range, F	Flux	Nature of Joint	Color of Braze	Uses
Furnace, dip	1150–1185	Essential	Lap. Clearance <0.010 in. for laps $<¼$ in. long; but >0.025 in. for longer laps	Gray	Wrought Al alloys: 1100, 3003, 3004, 5050, 6951, 6053, 6061, 6062, 6063. Cast Al alloys: A612, C612
Furnace	1120–1140			Gray	
Furnace, dip	1060–1185			Gray	
Torch	1090–1185			Gray	
All methods[b]	1450–1700	Self-fluxing on copper; flux rec on other metals	Clearance: 0.002–0.005 in.[e]	Lt Gray[a]	Cu, Cu alloys; limited use for Ag, W, Mo. Do not use on ferrous alloys containing more than 10% Ni. Not rec for sulfurous atm above room temp
	1350–1550		Clearance: 0.001–0.003 in.[e]	Lt Gray	
	1300–1550		Clearance: 0.002–0.005 in.[e]	Lt Gray	
	1300–1500		Clearance: 0.001–0.003 in.[e]	Lt Gray	
	1300–1500		Clearance: 0.003–0.005 in.[e]	Lt Gray	
All methods[d]	1145–1400	Required unless brazing is done in vacuum or inert atm	Lap rec; butt sometimes used. Clearances 0.002–0.005 in. Fatigue str about that of metals being joined (to 27,000 psi). Tough, ductile, high impact str; ten str, 50–60,000 psi	Lt Yellow	Unstabilized types of stainless[e]
	1295–1550			Lt yellow	Where tolerances cannot be as closely controlled[e]
	1270–1500			Whitish yellow	Joining carbide tool tips to tool shanks[e]
	1435–1650			Lt yellow	Carbide tip brazing[e]
	1370–1550			Lt yellow	Elec equip.; food and dairy equip. where Cd-containing alloys might be prohibited[e]
	1425–1600			Lt yellow	Same as above
	1205–1400			Whitish	Food and dairy equip.[e]
	1435–1650			White	Assembling electronic tubes[e]
	1325–1550			Whitish	Particularly with sterling silver[e,f]
	1390–1600			Whitish	Same as above
	1450–1650			Whitish	Same as above
Induction, furnace, resistance	1815–2000	None[g]	—	Copperish	Special alloy for joining parts in electron tube assemblies
Same as above	1630–1850	None[g]	—	Copperish	Same as above
Furnace[h]	2000–2100	None[i]	Clearance: 0.000–0.002 in.[j]	Yellow	Ferrous metals; Ni and Cu-N alloys
Torch, furnace, induction	1670–1750	Required; borax-boric acid commonly used	Lap, butt; clearances 0.002–0.005 in. High str in shear and tension	Yellow	Steels, Ni and Cu alloys
"	1670–1750			Yellow	Same as above
"	1670–1750			Yellow	Same as above
"	1600–1700			Pale yellow	Steels, Ni alloys
"	1620–1700			Grayish yellow	Same as above
All methods	1720–1800			Gray	Same as above
All methods	1690–1800			Gray	Same as above
Torch, furnace, dip; sometimes others except resistance	1120–1160	Req; fluxes contain KCl, NaCl, some fluorides	Lap; clearances 0.004–0.010 in.	Gray	Mg alloy M1A
Furnace, generally using controlled dry H_2 atm	2000–2150	None in red. atm; otherwise necessary	Variable	Gray	Stainless steels, high Ni alloys; jet engines
Same as above	1780–2100	Same as above	Variable	Gray	Stainless steels, high Ni alloys; lower temp than BNiCr

[f] Variation in brazing temp permits step brazing.

[h] Using H_2 or dissociated ammonia atmosphere.

[j] Otherwise same nature as CuZn alloys.

[g] In reducing atmosphere or vacuum; otherwise borax-boric acid flux.

[i] Except on metals with oxide constituents.

[k] Total Fe + Si + C = 10% max.

Welding Electrodes and Rods

Classification

Welding rods and electrodes are generally grouped broadly according to the major metal (or metals) of which they are composed. Some are also grouped by the metals which they are used to weld. (These two classifications are often identical because it is usually desirable to weld base metals with a filler metal of similar composition.) A few groups of rods and electrodes are also defined by the welding method with which they are used.

Each broad group of rods and electrodes is further classified according to one or more of the following factors: chemical composition; coating, current and welding position; mechanical properties; appearance of the weld; intended end use. The key chart on the opposite page indicates the method of classifying

EXPLANATION OF AWS-ASTM ROD AND ELECTRODE CLASSIFICATION NUMBERS
(And Key to the Charts in This Welding Section)

Electrode or Rod Group ↓	AWS-ASTM Spec	Sample Class No.[a]	Type of Specified Conditions Indicated by Class No.[b]	See Table No. . . .
WELDING IRONS AND STEELS				
Mild Steel (coated and covered)	A233–58T	E6010	60—properties; 10—manner of use[c]	2a, 2b
Low Alloy Steel (covered)	A316–58T	E7010[e]	70—properties; 10—manner of use	2a, 2b
		E7010–A1[e]	70—properties; 10—modifies comp; A1—comp of weld	2a, 2c
Stainless Steel (covered)	A251–46T	E308ELC–15	308—comp of weld; ELC—modifies comp; 15—manner of use. Properties are also specified[d]	3
Stainless Steel (bare)[f]	A371–53T	ER308L	308—comp as mfd; L—modifies comp	3
For Welding Cast Iron[g]	A398–56T	RCuAl–A2	CuAl—comp as mfd; A2—modifies comp. Visual examination of weld is also specified[d]	4
For Gas Welding Irons and Steels	A251–46T	GA65	A65—properties	5
WELDING NONFERROUS METALS				
Copper and Copper Alloy	B225–53T (electrodes)	ECuAl–A2	CuAl—comp as mfd; A2—modifies comp. Properties are also specified[d]	6
	B259–52T (rods)	RCuAl–A2	CuAl—comp as mfd; A2—modifies comp	6
Nickel and Nickel Alloy	B295–54T (covered electrodes)	E3N10[h]	3—base metal; 1—welding method; 0—comp of core as mfd. Comp of weld, tensile strength are also specified[d]	7
	B304–56T (bare electrodes and rods)	ERN60	6—welding method; 0—comp as mfd	8
Aluminum and Aluminum Alloy	B184–43T (covered electrodes)	Al–2	2—comp of core as mfd	9
	B285–54T (bare electrodes and rods)	R–CN42A[i]	CN42—comp as mfd	9
Magnesium and Magnesium Alloy[f]	No specifications; alloys can be joined by gas welding and inert-gas shielded arc processes. In general, filler metal should have same composition as alloy being joined			
Lead and Zinc	No specifications; gas welding most commonly used. In general, filler metal should have same composition as alloy being joined			

[a] The first letter of the designation is either "E" for electrode or "R" for rod.

[b] The figures used are samples, e.g., the "10" for mild steels may be 11, 12, etc., each indicating a different manner of use. Properties = Mechanical properties of the deposited weld metal. (The figures approximate the minimum tensile strength in units of 1000 psi.) Manner of use = Type of current, polarity (if d.c.), welding position, type of covering.

[c] These figures also indicate modifications of specified properties and whether or not weld composition is specified.

[d] Specified, but not represented in the classification number.

[e] Must be classified one way or the other, not both.

[f] Used as both rods and bare electrodes. As rods—atomic hydrogen and inert-gas metal arc (nonconsumable electrode) welding. As bare electrodes—submerged arc and inert-gas metal-arc (consumable electrode) welding.

[g] Includes rods for oxyacetylene and carbon arc welding, covered electrodes for shielded metal arc welding. Types included here are: cast iron, copper-base, nickel-base and mild steel.

[h] The "N" designates "nickel."

[i] The "A" designates "aluminum."

1—TYPICAL PROPERTIES OF MILD STEEL ARC WELDED DEPOSITS

AWS—ASTM Class ⬇	Ten Str, 1000 psi	Yld Point, 1000 psi	Elong (in 2 in.), %	Red. of Area, %	Impact Str, ft-lb[a]	Endur Limit, 1000 psi	Brinell Hardness
E4510, E4520	45	—	5	—	—	—	—
E6010	60–68	48–58	22–28	35–60	30–40, 15–25	28–32	140–160
E6011	60–70	48–61	22–30	35–60	30–40, 15–25	28–32	140–160
E6012	60–78	48–65	17–22	20–40	20–30, 5–15	—	150–170
E6013	60–78	48–65	17–22	25–50	25–35, 5–20	—	150–170
E6020, E6030	60–68	48–58	25–30	40–60	25–35, 15–25	30–34	150–170
E6027	60–68	48–55	25–30	40–60	25–35, 15–25	30–34	150–170
E6014	60–72	48–60	17–25	30–50	25–35, 15–25	—	—
E7014	70–85	58–77	17–25	30–50	25–35, 15–25	—	—
E6015, 6016	60–72	48–60	22–35	55–75	35–50, 25–40	—	140–160
E7015, 7016	70–76	58–62	22–35	55–75	35–50, 25–40	—	—
E6018	60–72	48–60	22–30	55–75	35–50, 25–40	—	—
E7018	70–85	58–70	22–30	55–75	35–50, 25–40	—	—
E6024	60–72	48–60	17–22	20–40	25–35, 10–20	—	150–170
E7024	70–85	58–75	17–22	20–40	25–35, 10–20	—	150–170
E6028	60–72	48–60	22–30	55–75	35–50, 25–40	—	—
E7028	70–85	58–74	22–30	55–75	35–50, 25–40	—	—

[a] Charpy keyhole. First value is at 70 F, second at −40 F.

each group according to American Welding Society specifications.

In some cases there is a choice offered by the specification; the manufacturer may be allowed to select one of several classification methods, or may be allowed to list an electrode by more than one classification.

The numbered charts on this and the following six pages classify the rods and electrodes within each group by the applicable method and also give other information, such as method of use, typical properties and some common applications.

Welding Processes

Arc welding. A group of processes wherein coalescence is produced by heating with an electric arc. The metal to be welded is one pole of an electric circuit and the electrode is the other pole. A suitable gap forms a heat generating arc. (The metal participates in the production of heat but is not the sole source.) Carbon or metal electrodes may be used. If covered metal electrodes are used the process is referred to as *shielded*. There are other methods of shielding, such as using an inert gas (helium or argon), or a blanket of granular, fusible material on the work (referred to as *submerged arc welding*).

Braze welding. Uses a brazing torch but is classified technically as a welding process because the filler metal is distributed by gravity and not, as in brazing, by capillary action.

Gas welding. A group of processes wherein coalescence is produced by heating with a gas flame, most commonly obtained by the combustion of acetylene with oxygen (*oxyacetylene welding*).

Resistance welding. A group of processes wherein coalescence is produced by the heat generated from resistance to flow of electric current through the work, and by pressure. Heat is generated in two places: in the body of the work where only the resistivity of the material determines the amount of heat; and at contact surfaces where resistivity is affected by pressure, surface oxides and compounds, and surface roughness and cleanliness. No fluxes or filler metals are used. Various types of resistance welding processes are named according to the method of determining pressure points. Examples

Definitions

Filler metal. A broad term for the metal added in making a weld. It may or may not carry electric current.

Rod. Filler metal, in wire or rod form, which does not carry current. Rods are used in gas welding or in arc welding with a separate carbon or tungsten electrode.

Electrode. The current-carrying element. With three exceptions, it is also the filler metal. Carbon and tungsten electrodes are not filler metals. The third exception is the "resistance welding electrode," a term applied to the part of the resistance welding machine that transmits current (and usually pressure) to the work. A resistance welding electrode may be in the form of a wheel, bar, cylinder, clamp, etc.

Bare, lightly coated, covered. Terms which apply to filler metals (either rods or electrodes) used in arc welding. However, since rods are usually bare, the terms are generally reserved for filler metal electrodes. The purpose of a light coating is primarily to stabilize the arc. "Covered" wires have a relatively thick coating which protects the molten metal from the atmosphere, improves weld metal properties, and stabilizes the arc.

Welding Electrodes and Rods

2a—MILD AND LOW ALLOY STEEL COVERED ELECTRODES
(Classified by Current, Welding Position and Covering)

AWS-ASTM Class ⬇	Current, Polarity	Welding Position[a]	Covering	Slag[b]	Deposition Rate	Arc Characteristics
Exx10[c]	D.c. reversed	F, V, OH, H	High cellulose sodium	Thin	Slow	Spray, deep penetration
E6011	A.c. or d.c. reversed	F, V, OH, H	High cellulose potassium	Thin	Slow	Spray, deep penetration
E6012	A.c. or d.c.	F, V, OH, H	High titania sodium	Dense	Medium	Globule, medium penetration
Exx13	A.c. or d.c. straight	F, V, OH, H	High titania potassium	Medium	Med fast	Globule, shallow penetration
Exx14	A.c. or d.c.	F, V, OH, H	Iron powder, titania	Medium	Med fast	Globule, medium penetration
Exx15	D.c. reversed	F, V, OH, H	Low hydrogen sodium	Heavy	Medium	Globule, medium penetration
Exx16	A.c. or d.c. reversed	F, V, OH, H	Low hydrogen potassium	Heavy	Medium	Globule, medium penetration
Exx18	A.c. or d.c. reversed	F, V, OH, H	Iron powder, low hydrogen	Heavy	Fast	Globule, shallow penetration
Exx20[a]	A.c. or d.c.	H fillets, F	High iron oxide	Heavy	Fast	Spray, medium penetration
E6024	A.c. or d.c. either polarity	H fillets, F	Iron powder, titania	Heavy	Fast	Spray, shallow penetration
E6027	A.c. or d.c.	H fillets, F	Iron powder, iron oxide	Heavy	Fast	Spray, medium penetration
Exx28	A.c. or d.c. reversed	H fillets, F	Iron powder, low hydrogen	Dense	Fast	Spray, deep penetration
E6030	A.c. or d.c. either polarity	F	High iron oxide	Dense	Fast	Spray, deep penetration

[a] F = flat, V = vertical, OH = overhead, H = horizontal.

[b] All slag deposits are readily removable except E6012 which is rated "fair."

[c] When xx = 45, the only column in this table that applies is "Welding Position." Current and polarity of 4510 and 4520 are not specified, but generally d.c. straight polarity is used. These two electrodes are not covered but are either sulcoated or light coated.

2b—MILD AND LOW ALLOY STEEL COVERED ELECTRODES
(Classified by Minimum Mechanical Properties)[a, b]

AWS-ASTM Class ⬇	Ten Str, 1000 psi	Yld Point, 1000 psi	Elong (in 2 in.), %
MILD ALLOY STEEL ELECTRODES			
4510, 4520	45	Not spec	5
6010, 6011	62	50	22
6012, 6013, 6014, 6024	67	55	17
6015, 6016, 6018, 6028	67	55	22
6020, 6027, 6030	62	50	25
LOW ALLOY STEEL ELECTRODES			
70xx	70	57	22[c]
80xx	80	67	19[d]
90xx	90	77	17[e]
100xx	100	87	16[f]
110xx	110	97	15
120xx	120	107	14

[a] Classification by mechanical properties is represented by the first two digits. For low alloy steel electrodes the digits are exactly the minimum tensile strength in units of 1000 psi. For mild alloy steel the digits are approximately the minimum tensile strength.

[b] Chemical composition of low alloy steel welds is an alternative classification (see 2c). Chemical composition of mild alloy steel welds is additionally specified for electrodes of the following classes: Exx14–15–16–18–24–28. For these classes the maximum percentage composition is: Mo 0.30, Cr 0.20, Mn 1.25, Ni 0.30, V 0.08 (in addition the sum total of these elements shall not exceed 1.50%) and Si 0.90.

[c] Elongation is 25% for 7020.

[d] Elongation is 16% for 8013.

[e] Elongation is 14% for 9013.

[f] Elongation is 13% for 10013.

2c—LOW ALLOY STEEL COVERED ELECTRODES
(Classified by Chemical Composition of Weld)[a]

⬇ AWS-ASTM Class	Composition (max), %
CARBON-MOLYBDENUM STEEL	
A1	C 0.12, Mo 0.40–0.65
CHROMIUM-MOLYBDENUM STEEL	
B1	C 0.12, Cr 0.40–0.65, Mo 0.40–0.65
B2L	C 0.05, Cr 1.00–1.50, Mo 0.40–0.65
B2	C 0.12, Cr 1.00–1.50, Mo 0.40–0.65
B3L	C 0.05, Cr 2.00–2.50, Mo 0.90–1.20
B3	C 0.12, Cr 2.00–2.50, Mo 0.90–1.20
B4L	C 0.05, Cr 1.75–2.25, Mo 0.40–0.65
NICKEL STEEL	
C1	C 0.12, Ni 2.00–2.75
C2	C 0.12, Ni 3.00–3.75
C3	C 0.12, Ni 0.80–1.10
MANGANESE-MOLYBDENUM STEEL	
D1	C 0.12, Mo 0.25–0.45, Mn 1.25–1.75
D2	C 0.15, Mo 0.25–0.45, Mn 1.65–2.00
OTHER (min %)[b]	
G	Mo 0.20, Cr 0.30, Mn 1.00, Si 0.80, Ni 0.50, V 0.10

[a] Classification of low alloy steel electrodes by chemical composition can be found in AWS-ASTM specification A316-58T. Compositions are represented by a code following the standard classification, modified by the second two digits. This table gives only the percentages of the major elements.

[b] Deposit need have minimum of only one of elements listed.

are: *spot welding* (two welding tips pressing the work together in one spot at a time); and *projection welding* (welding dies are used and pressure points determined by projections designed as an integral part of the work). Other processes are named according to the speed of effecting contact and pressure and their timing with reference to the heating cycle (*flash* and *upset*).

3—STAINLESS STEEL RODS AND ELECTRODES

Covered Electrodes		Rods and Bare Electrodes		Applications	Min Mechanical Properties of Covered Electrode Deposits	
AWS-ASTM Class[a] ↓	Major Composition of Weld Metal, %[b]	AWS-ASTM Class[c] ↓	Major Composition As Manufactured, %[b]		Ten Str, 1000 psi	Elong (in 2 in.), %
E308......	C 0.08, Cr 18.0–21.0, Ni 9.0–11.0	**ER308....**	C 0.08, Cr 19.5–22.0, Ni 9.0–11.0	Weld base metal of similar composition	80	35
E308ELC..	C 0.04, Cr 18.0–21.0, Ni 9.0–11.0	**ER308L...**	C 0.03, Cr 19.5–22.0, Ni 9.0–11.0	Low C reduces carbide precipitation, avoiding intergranular corrosion without need for stabilizers	75	35
E309......	C 0.15, Cr 22.0–25.0, Ni 12.0–14.0	**ER309....**	C 0.12, Cr 23.0–25.0, Ni 12.0–14.0	Weld similar alloys, wrought or cast. Weld 18-8 for severe corrosion conditions	80	35
309Cb......	C 0.12, Cr 22.0–25.0, Ni 12.0–14.0, Cb+Ta 0.70–1.00	....	....	Primarily weld type 347 clad steel or dissimilar metals. Cb stabilizes against intergranular corrosion, provides high strength at high temperatures	80	30
E309Mo...	C 0.12, Cr 22.0–25.0, Ni 12.0–14.0, Mo 2.00–3.00	....	....	Primarily weld type 316 clad steels or dissimilar metals (similar to E309 with Mo added, C reduced)	80	35
E310......	C 0.20, Cr 25.0–28.0, Ni 20.0–22.0	**ER310....**	C 0.08–0.15, Cr 25.0,[d] Ni 20.0[d]	High strength, ductility useful in welding such hardenable steels as armor plate Also weld clad steels	80	30
E310Cb....	C 0.12, Cr 25 0–28.0, Ni 20.0–22.0, Cb+Ta 0.70–1.00	....	....	Same uses as E309Cb	80	25
E310Mo...	C 0.12, Cr 25.0–28.0, Ni 20.0–22.0, Mo 2.00–3.00	....	....	Same uses as E309Mo	80	30
E312......	C 0.15, Cr 26.0–31.0, Ni 8.5–10.5	....	....	Primarily weld cast alloys of similar composition. A recent use: weld dissimilar metals when one is high in nickel	95	22
E316......	C 0.08, Cr 17.0–20.0, Ni 11.0–14.0, Mo 2.00–2.50	**ER316....**	C 0.08, Cr 18.0–20.0, Ni 12.0–14.0, Mo 2.0–2.5	Weld similar alloys containing 2 to 3% Mo. Molybdenum content provides creep resistance at high temperatures	80	30
E316ELC..	C 0.04, Cr 17.0–20.0, Ni 11.0–14.0, Mo 2.00–2.50	**ER316L...**	C 0.03, Cr 18.0–20.0, Ni 12.0–14.0, Mo 2.0–2.5	Primarily weld extra low carbon, molybdenum-bearing austenitic alloys	75	30
E317......	C 0.08, Cr 18.0–21.0, Ni 12.0–14.0, Mo 3.00–4.00	**ER317....**	C 0.08, Cr 18.5–20.5, Ni 13.0–15.0, Mo 3.25–4.0	Weld similar alloys that must meet severe corrosion requirements involving sulfuric and sulfurous acids, salts	80	30
E318......	C 0.08, Cr 17.0–20.0, Ni 11.0–14.0, Mo 2.00–2.50, Cb+Ta 1.00[e]	....	....	Primarily weld metals of similar composition (identical to E316 with Cb added)	80	25
E330......	C 0.25, Cr 14.0–17.0, Ni 33.0 min	**ER330....**	C 0.15–0.25, Cr 15.0–17.0, Ni 34.0[d]	Repair defects in alloy castings; weld similar alloys. Nickel content gives heat and scale resistance above 1800 F	75	25
E347......	C 0.18, Cr 18.0–21.0, Ni 9.0–11.0, Cb+Ta 1.00[f]	**ER347....**	C 0.08, Cr 18.5–21.0, Ni 8.5–10.5, Cb+Ta 1.00[g]	Usually weld Cr-Ni alloys of similar composition stabilized with Cb or Ti	80	30
E410......	C 0.12, Cr 11.0–14.0, Ni 0.60	**ER410....**	C 0.07–0.12, Cr 12.0–14.0, Ni 0.6, Mo 0.6	Weld similar alloys; deposit overlays on carbon steels for corrosion, erosion and abrasion resistance. Air-hardening, it requires preheat and post-heat treatment to obtain ductility	70	20
....	....	**ER420....**	C 0.25–0.40, Cr 12.0–14.0, Ni 0.6	Similar to E410, but better resistance to corrosion, abrasion	—	—
E430......	C 0.10, Cr 15.0–18.0, Ni 0.60	**ER430....**	C 0.10, Cr 15.5–17.0, Ni 0.6	Similar to E410. Cr limit gives adequate corrosion resistance, yet retains ductility	70	20
E502.......	C 0.10, Cr 4.0–6.0, Ni 0.40, Mo 0.45–0.65	**ER502....**	C 0.10, Cr 4.5–6.0, Ni 0.4, Mo 0.45–0.65	Weld similar metals, usually pipe or tubing	60	20

[a] The complete classification numbers are *Exxx-15* or *Exxx-16*. The *-15* suffix indicates a lime covering, *-16* a lime or titania covering. Polarity and welding position requirements are the same as those listed in chart 2 for Exx-15 and Exx-16.

[b] Maximum percentages unless otherwise specified. Carbon analysis required to nearest 0.01%.

[c] For consumable electrode welding, d.c. reversed polarity is preferred.

[d] Minimum. [e] Minimum is 6 x C. [f] Minimum is 8 x C. [g] Minimum is 10 x C.

continued on next page

Welding Electrodes and Rods

4—RODS AND ELECTRODES FOR WELDING CAST IRON

AWS-ASTM Class[a] ↓	Common Name[b]	Welding Method	Remarks	Uses
RCl	Cast iron	Oxyacetylene	Produces machinable deposit of same color, composition and structure as base metal	Fill in or build up new or worn gray iron castings. General fabrication, salvage, repair
ECI	Cast iron	Arc; a.c. or d.c. reversed polarity	Basically RCI with heavy covering. Weld metal flows readily; light slag easily removable	Weld and repair gray iron castings; faster than oxyacetylene for repairing small defects
RCI-A	Alloy cast iron	Oxyacetylene	Similar to RCI but higher melting. Weld metal more fluid; welding more rapid	Gray or alloy cast iron to obtain greater tensile strength and finer grain structure than RCI
RCuZn-A[c]	Naval brass	Oxyacetylene	Better strength, corr res than basic 60 Cu-40% Zn alloy. Deposits 70–90 Bhn	Where color match is not required and weldments are not subject to electrolytic corrosion or high temperature service
RCuZn-B[c]	Manganese bronze	Oxyacetylene	Better strength, hardness, corr res than 60 Cu-40% Zn alloy. Deposits 80–110 Bhn	Same as above
RCuZn-C[c]	Low-fuming bronze	Oxyacetylene	Diminishes zinc oxidation (fuming). Slightly higher mechanical properties than naval brass or manganese bronze; deposits 80–110 Bhn	Same as above
RCuZn-D[c]	Nickel bronze	Oxyacetylene	Color is silver rather than yellow. Low fuming. Deposits 90–110 Bhn	Same as above
ECuAl-A2[d], RCuAl-A2[c]	Aluminum bronze (9–11 Al, 1.5% Fe)	Electrodes—arc welding; a.c. and d.c. reversed polarity. Rods—carbon arc welding	Low m.p. permits rapid welding to minimize distortion. Yld and ten str twice those of ECuSn alloys (below)	Weld the new higher strength cast irons. Overlay corrosion and wear resistant surfaces
ECuSn-A[d]	Phosphor bronze (4.8–5.8% Sn)	Arc; d.c. reversed polarity	Deposits 70–85 Bhn	Weld cast iron and overlay bearing and corrosion resistant surfaces
ECuSn-C[d]	Phosphor bronze (7.0–9.0% Sn)	Same as above	Deposits 85–100 Bhn. Higher yld and ten str than ECuSn-A	Same as above
ENi	Nickel	Arc; flat specified but other positions have been used	Rapid, widely used. Even without preheating, deposits can be machined	Weld ordinary gray irons to themselves or to other ferrous and nonferrous materials; light and medium-sized castings. Reclamation and repair
ENiFe	Nickel-iron	Same as above	Same as above, but higher ten str and ductility	Weld various cast irons to steel and other ferrous and nonferrous materials; heavy and highly stressed sections. Better than ENiFe for castings containing more than 0.20% P
ENiCu-A	Nickel-copper (55–60% Ni)	Same as above	Similar to ENiFe	Similar to ENiFe
ENiCu-B	Nickel-copper (63–70% Ni)	Same as above	Similar to ENi	Similar to ENi
ESt	Mild steel	Arc; a.c. or d.c. reversed polarity	Designated specifically for cast iron; has a low m.p. Covering and deposits not readily machinable	Largely confined to repair of small pits and cracks in cast iron; some larger repairs if casting requires no machining

[a] Chemical symbols for the major elements of the composition are used to classify these rods and electrodes. In other cases, CI = cast iron and St = steel. The letter, or letter and number, following the hyphen indicates a modification of a standard composition.

[b] For exact chemical composition as manufactured, see ASTM A398–56T.

[c] Also a standard classification under Copper and Copper Alloy Welding Rods.

[d] Also a standard classification under Copper and Copper Alloy Welding Electrodes.

Other welding processes. Each process has variants not described and less commonly used. There are also special processes such as *flow welding, forge welding, thermit welding* and *induction welding.* All of these are described in detail in the *Welding Handbook* of the American Welding Society.

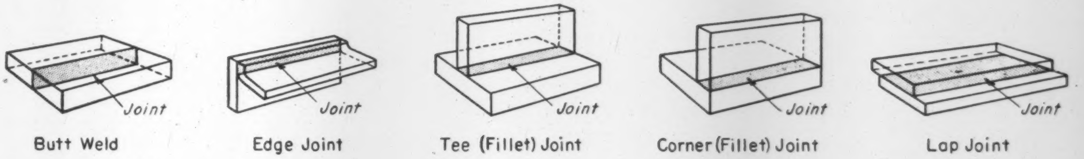

Joint
Joint
Joint
Joint
Joint
Butt Weld
Edge Joint
Tee (Fillet) Joint
Corner (Fillet) Joint
Lap Joint

***Fig 1**—The five basic welding joint designs.*

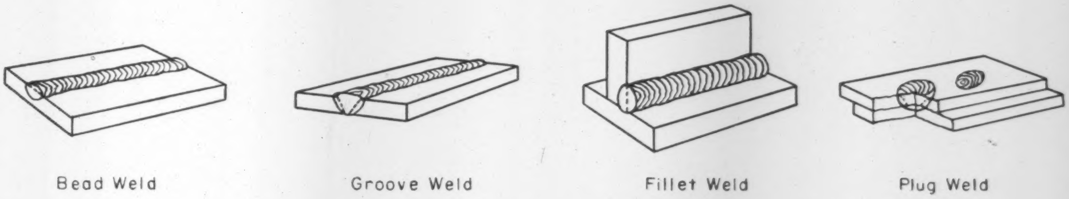

Bead Weld
Groove Weld
Fillet Weld
Plug Weld

***Fig 2**—The four basic weld types for arc and gas welding.*

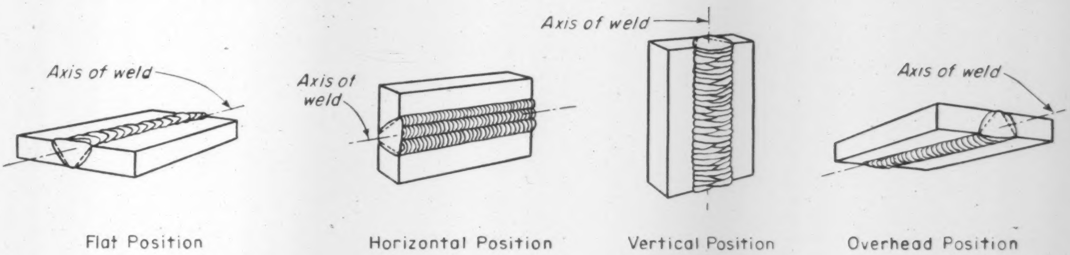

Axis of weld
Axis of weld
Axis of weld
Axis of weld
Flat Position
Horizontal Position
Vertical Position
Overhead Position

***Fig 3**—The four basic welding positions.*

5—RODS FOR GAS WELDING IRONS AND STEELS [a]

AWS-ASTM Class ↓	Weld Treatment[b]	Min Ten Str, 1000 psi	Min Elong (in 2 in.), %
GA65	SR	65	20
	NSR	72	17
GA60	SR	60	25
	NSR	62	20
GA50	SR	50	28
	NSR	52	23
GB65	SR	65	18
	NSR	72	15
GB60	SR	60	20
	NSR	62	15
GB45	NSR	45	—

[a] Mechanical tests are performed on welds made by either 3/16- or 1/4-in. rods and on plates 3/4 in. thick (except GB45 which requires a 3/8-in. plate).

[b] SR = stress relieved; NSR = non-stress relieved

Design Factors

Welding is a basic production method whose end product is a metal part or form termed a "weldment." Weldments must be considered in competition with castings, forgings and other fabricated forms, as well as other joining methods.

Sizes and shapes. A wide range of thicknesses, sizes and shapes can be joined by welding. Parts as thin as 1 mil and as thick as 20 in. have been welded commercially. Plate and sheet stock are the most widely used forms, but forgings, castings, extrusions and rolled shapes are also used in fabricating weldments.

Tolerances. The two principal factors influencing tolerances are distortion from the welding operation and the tolerances of the metal forms that make up the weldment. The tolerances on the various metal forms, such as flat stock, castings, forgings and rolled sections, are easily obtainable. But degree of welding distortion is a function of a great many things, and exact values cannot be given. The following tolerances seem to be those most commonly achieved:

1. Small parts containing very little welding, 1/8 in.
2. Moderately large parts containing a small amount of welding, 1/4 in.
3. Large structures containing moderate amounts of welding, 3/8 in.
4. Large, complicated structures, and structures containing large amounts of welding, 3/8 to 1/2 in.

continued on next page

Welding Electrodes and Rods

6—COPPER AND COPPER ALLOY RODS AND ELECTRODES

AWS-ASTM Class ↓	Common Name	Welding Method[a]	Current, Polarity	Min Ten Str, 1000 psi	Brinell Hardness	Applications
ECu, RCu	Copper	IGMA (E, R), CA (R), OG (R)	D.c. straight	25	25–40[b]	Light gage Cu up to $\frac{3}{16}$ in.—R[c]; heavier gage—E. Deoxidized Cu (R)[e, f]
ECuSi, RCuSi-A	Silicon bronze (Si 2.8–4.0%)	IGMA (E, R), SMA (E), CA (R), OG (R)	D.c. reverse (E), d.c. straight (R)	50	80–100	Primarily for welding Cu, CuSi and CuZn to themselves (E, R) and to steel (R)[c, f]. Mtl over $\frac{1}{16}$ in. thk (E).[d] Silicon bronze; overlay for corr res (E)[g]. CuSi alloys (R)[e]
RCuSi-B	Silicon bronze (Si 1.02–2.0%)	CA, OG	D.c. straight	35	60–85	Red brass piping[e]. Cu, CuSi and CuZn[f]; Cu to steel[f]; galvanized iron[f]
RCuSn	Phosphor bronze (Sn 4.0–6.0%)	CA, IGMA-NC	D.c. straight	35	70–85	Cu[c, f] and CuSn[e]
ECuSn-A[i]	Phosphor bronze (Sn 4.8–5.8%)	SMA, IGMA-C	D.c. reverse	35	70–85	Weld phosphor bronzes of similar comp. "A" and "C" (below) used interchangeably for Cu, brasses, bronzes, cast iron, dissimilar metals
ECuSn-C[i]	Phosphor bronze (Sn 7.0–9.0%)	SMA, IGMA-C	D.c. reverse	40	85–100	Same as above, but "C" provides higher ten and yld str, higher hardness
ECuNi, RCuNi	Copper nickel	SMA (E), OG (R), IGMA-NC(R)	D.c. reverse (E), d.c. straight (R), a.c. (R)	50	60–80	CuNi alloys (10–30%) to themselves to provide good corr res
RCuZn-A[i]	Naval brass	BW, OG	—	50	70–90	Brass[e]. Cu, bronze, Ni alloys, steel, cast and malleable iron[h]
RCuZn-B[i]	Manganese bronze	BW	—	55	80–110	Steel and cast iron[h]. As surfacing filler metal for building up bearings
RCuZN-C[i]	Low-fuming bronze	BW, OG	—	57	80–110	General purpose
RCuZn-D[i]	Nickel bronze	BW, OG	—	60	90–110	Steel and cast iron[h]
ECuAl-Al, RCuAl-Al	Aluminum bronze (iron-free)	IGMA (E, R), CA (R)	D.c. reverse (E), a.c. (R)[e], d.c. straight (R)[c, f]	55	100–158 (E), 100–130 (R)[f], 100–150 (R)[c]	Annealed aluminum bronze plate, sheet and strip (E, R). Repair castings (E, R)[c, f]. Overlay bearing and corr res surfaces (E, R)[e]
ECuAl-A2[i], **RCuAl-A2**[i]	Aluminum bronze (Fe 3.0–4.25%)	IGMA (E, R), SMA (E), CA (R)	D.c. reverse (E)[d, g], d.c. straight (R)[c, f], a.c. (E[g], R[c])	60 (E), 65 (R)	130–150 (E)[g], 150–170 (E)[d], 100–130 (R)[d], 100–150 (R)[c]	Aluminum bronze, high str CuZn alloys, silicon bronze, nickel alloys, ferrous alloys, dissimilar metals. Repair castings; overlay bearing and corr res surfaces
ECuAl-B, RCuAl-B	Aluminum bronze (Fe 3.0–4.25%)	SMA (E), CA (R), IGMA-NC(R)	D.c. reverse (E), d.c. straight (R)[c,d], a.c. (E, R[c])	65 (E), 70 (R)	140–180 (E), 140–180 (R)[f], 180–220 (R)[c]	Similar to above, but provides higher phys prop. Weld nonferrous metals to steel (E,R)[e]

[a] Method symbols are: IGMA = inert-gas metal arc welding (–C = consumable electrode; –NC = nonconsumable electrode); OG = oxyacetylene welding, CA = carbon arc welding, SMA = shielded metal arc welding (covered electrodes), BW = braze welding.

[b] Rockwell F.

[c] Inert-gas metal arc (nonconsumable electrode) welding.

[d] Inert-gas metal arc (consumable electrode) welding.

[e] Oxyacetylene welding.

[f] Carbon arc welding.

[g] Shielded metal arc welding (covered electrode).

[h] Braze welding.

[i] Also a standard classification under Rods and Electrodes for Welding Cast Iron.

Joint design. There are five fundamental types of arc or gas welded joints (see Fig 1) and four basic types of welds (see Fig 2), but variations of these are used to satisfy particular requirements. Resistance welding commonly employs the lap joint, although flash welding requires a butt joint.

Welding positions. Welds are classified by four basic positions; for each, certain electrodes are recommended or not recommended. The position terms—flat, vertical, horizontal and overhead—can be applied to all types of welds, but they are illustrated here for the groove weld (see Fig 3).

7—NICKEL AND NICKEL ALLOY COVERED ELECTRODES [a]

AWS-ASTM Class[b] ↓	Alloy	Common Name	Min Ten Str, 1000 psi
E3N10.........	Nickel-copper (C 0.40, Mn 4, Cb+Ta 0%)	Monel[c,d]	70
E3N11.........	Nickel (C 0.75)	Nickel[c]	55
E3N12.........	Nickel-chromium-iron	Inconel[c]	80
E3N14.........	Nickel-copper-aluminum	K monel[e]	100[f]
E3N19.........	Nickel-chromium-iron-titanium	Inconel X	115[f]
E3N1B, E4NiB..	Nickel-molybdenum	Hastelloy B[g]	100
E3N1C, E4NiC..	Nickel-molybdenum-chromium	Hastelloy C[g]	100
E4N10.........	Nickel-copper (C 0.15, Mn 2.50, Cb+Ta 3%)	Monel	—
E4N11.........	Nickel (C 0.10%)	Nickel	—
E4N12.........	Nickel-chromium	Inconel	—

[a] Used with shielded metal arc welding process.

[b] These electrodes are used to join alloys of same composition as the electrode. When first digit of designation is 3, electrode is used primarily to join similar alloys to themselves; when first digit is 4, electrode is used to weld a nickel or nickel-base alloy to steel, to overlay a nickel or nickel-base alloy on steel, or to weld the clad side of nickel or a nickel-base alloy clad steel.

[c] Used to weld not only mill products but also castings of suitable welding quality.

[d] Also used to weld such copper-nickel alloys as 70–30, 80–20 and 90–10 to themselves.

[e] Also used for a number of dissimilar metal combinations.

[f] Age hardened.

[g] Also used to weld alloys of similar composition to steel-clad materials or other metals.

8—NICKEL AND NICKEL ALLOY RODS AND BARE ELECTRODES

AWS-ASTM Class[a] ↓	Alloy	Common Name	Welding Method[b]
RN40........	Nickel-copper (Mn 2, Al 0, Ti 0)	Monel	OG[c]
ERN60.......	Nickel-copper (Mn 1, Al 1.25, Ti 1.50–3.00)	Monel	IGMA, At. H_2
RN41........	Nickel (Mn 0.35, Fe 0.40, Ni 97 min, Al 0, Ti 0.50)	Nickel	OG[c]
ERN61.......	Nickel (Mn 1, Fe 1, Ni 93 min, Al 1.50, Ti 2.00–3.50)	Nickel	IGMA, At. H_2
RN42........	Nickel-chromium-iron (Ni 72 min, Cb+Ta 0)	Inconel	OG, IGMA[d]
ERN62.......	Nickel-chromium-iron (Ni 70 min, Cb+Ta 1.50–3.00)	Inconel	IGMA, At. H_2, OG
RN43........	Nickel-copper-silicon	—	OG[e]
ERN64.......	Nickel-copper-aluminum	K Monel	IGMA, At. H_2[f]
ERN69.......	Nickel-chromium-iron-titanium	Inconel X[g]	IGMA, At. H_2[f]
ERN6N.......	Nickel-chromium-titanium	Nimonic 7s	IGMA, At. H_2
ERN7B.......	Nickel-molybdenum	Hastelloy B	At. H_2, IGMA, Sub Arc
ERN7C.......	Nickel-molybdenum-chromium (Cr 14.5–16.5, Mo 15–17, W 3.00)	Hastelloy C	At. H_2, IGMA, Sub Arc
ERN7W......	Nickel-molybdenum-chromium (Cr 4–6, Mo 23–26, W 0)	Hastelloy W[h]	At. H_2, IGMA, Sub Arc

[a] These rods and electrodes are used to weld alloys of similar composition.

[b] For the IGMA process, argon and d.c. reversed polarity are preferred for electrodes; either argon or helium and d.c. straight polarity with rods. Welding method symbols used are: OG = oxyacetylene; IGMA = inert-gas metal arc; At. H_2 = atomic hydrogen; Sub Arc = submerged arc.

[c] Gross porosity usually results when arc welding is employed.

[d] Do not use inert-gas metal arc method on sheet ⅛ in. thick and heavier.

[e] Used to weld monel which has 55–60% Ni, or any monel when absence of flux desirable.

[f] Responds to age hardening.

[g] Used to weld Inconel X and Inconel W.

[h] Used to weld such dissimilar metal combinations as Cr-Ni-Fe steels to cast cobalt alloys.

9—ALUMINUM AND ALUMINUM ALLOY RODS AND ELECTRODES

AWS-ASTM Class ↓	Major Composition As Manufactured	Alloys Welded[a]
BARE ELECTRODES AND RODS[b]		
R-996A, E-996A......	Al 99.6 min	996A
R-990A, E-990A......	Al 99.0 min	990A, M1A, G1A, clad M1A
R-C4A...............	Cu 4.0–5.0	CS42A, C4A
R-CN42A.............	Cu 3.5–4.5, Ni 1.7–2.3	CN42A
R-CS41A, E-CS41A...	Cu 3.9–5.0, Si 0.50–1.2	Clad CS41A
R-G1A, E-G1A.......	Mg 1.0–1.8	M1A, G1A, clad M1A
R-GM50A, E-Gm50A.	Mg 4.9–5.6, Mn 0.05–0.20	MG11A, Gr20A, clad MG11A, GS42A, GS11A
R-GR20A, E-GR20A.	Mg 2.2–2.8, Cr 0.15–0.35	MG11A, GR20A, clad MG11A
R-GR40A, E-GR40A..	Mg 3.1–3.9, Cr 0.15–0.35	MG11A, GR20A, GS11A, clad MG11A, GS42A, GR40A
R-MG11A, E-MG11A.	Mn 1.0–1.5, Mg 0.8–1.3	MG11A, clad MG11A
R-S5B, E-S5B.......	Si 4.5–6.0, Bi 0.05	M1A, MG11A, G1A, GR20A, CS11A, clad M1A, clad MG11A, S5A
R-SC51A............	Si 4.5–5.5, Cu 1.0–1.5	SC51A
R-SG70A............	Si 6.5–7.5, Mg 0.20–0.40	SG70A
R-ZG61A............	Zn 5.2–6.0, Mg 0.50–0.65	ZG61A
COVERED ELECTRODES[c]		
Al-2................	Al 99.0 min	Pure aluminum (min ten str 12,000 psi)
Al-43...............	Si 4.5–6.0, Al bal	General purpose (min ten str 14,000 psi)

[a] These ASTM alloy designations apply to all forms except die castings.

[b] Welding methods include gas, shielded carbon arc, inert-gas metal arc and atomic hydrogen.

[c] Used with d.c. current, preferably in flat position.

Adhesives

Selection

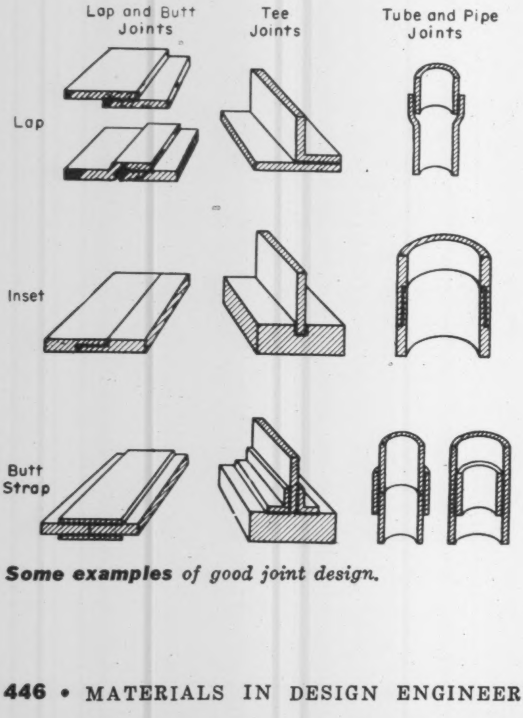
Classification. There are many ways to classify adhesives, none of which is satisfactory by itself. The five tables included here, each using a different breakdown, must therefore be referred to as a group. Classifying by chemical composition (Table 1) is most usual, but the newer modified compounds are omitted because they represent the blending of several chemical groups, and because the use of tradenames often obscures the chemical designation. In addition, in only a limited sense is the relationship between the type of materials being joined and the chemical type of the modified compounds a factor in selecting the adhesive.

These new adhesive "alloys" include: phenolic elastomers (e.g., phenolic-neoprene, phenolic-Buna N); vinyl phenolics (phenolic-vinyl, phenolic-polyvinyl butyral, phenolic-polyvinyl formal); modified epoxies (epoxy-phenolic, epoxy-polyamide, epoxy-polysulfide).

The other four tables apply to the single-resin adhesives as well as to these new modified compounds. In addition there are two factors which must be given more attention than the tables indicate:

Time. All classifications (as well as tack and bond strength properties) are related to time in various ways—shelf and pot life, tack life, length of time of application of heat and pressure, time lapse before handling parts, time lapse before end service.

End service conditions. Only by knowing and considering all the factors of end service, as well as all factors discussed in the tables here, can the formulator recommend a particular chemical composition with particular bonding requirements, vehicle, form and flowability. New formulations are devised where necessary. Also, it is not uncommon to use *two* adhesive formulations (allowing the first to dry before applying the second) to obtain the desirable advantages of each, or to obviate an undesirable effect of contact between the second adhesive and the surface.



***Some examples** of good joint design.*

Definitions

Emulsion. Adhesive type in which basic resin is a water-insoluble liquid (or solid particles) stably dispersed in water. Emulsifying agents are added to decrease surface tension. Some emulsions also contain a small amount of solvents (5%) to increase tackiness and improve water resistance.

Glue line thickness. Thickness of the fully dried adhesive layer.

Lay down thickness. Thickness of the applied wet adhesive coating.

100% reactive. Also "100% solids." Generally a modified epoxy resin-base paste, this adhesive type contains no solvent and cures at room temperature or higher.

Pot life. Length of time adhesive remains usable after being put into serviceable condition.

Shelf life. Length of time adhesive can be stored without deterioration (also known as "can stability").

Solvent dispersion. Adhesive type in which basic resin is in solvent solution and bonding is done by evaporation of the solvent (solvent release). A wide variety of solvents are used: ketones, toluol, naphtha, hydrocarbons, alcohol, acetone, etc. Solvent content generally varies from 10 to 50% for thermoplastic and thermosetting adhesives, from 50 to 95% for elastomeric.

Tack. The charateristic ("stickiness") that causes one surface, coated with adhesive, to adhere to another upon contact. Tack time may range from a few seconds to an almost indefinite period.

Wet strength. The bond strength realized immediately after adhesive-coated surfaces are joined and before cure occurs.

Methods

Adhesive bonding lends itself to complex automatic set-ups using spray guns, flow guns, paint rollers, etc. to apply the adhesive; pressure rolls, heavy presses, ovens, autoclaves, etc. to develop the bond. However, hand bonding with solvent-dispersed adhesives is common, and an understanding of the five steps involved can be applied to other methods:

1. Surface preparation—Surfaces should be smooth; must be clean and dry. Precleaning generally involves abrasive or chemical cleaning (ceramics, metals), light sanding (wood), chemical removal of mold release or plasticizer bloom (rubber, plastics), etc.

2. Adhesive preparation—Placing adhesive in a serviceable state may require mixing, thinning, reactivating, etc.

3. Applying adhesive—Varies from sticking coated film or tape or nameplate in place to use of trowel, squeeze bottle, hand roller, brush, etc.

1—CLASSIFIED BY CHEMICAL COMPOSITION GROUP

Type ➡	Natural	Thermoplastic	Thermosetting	Elastomeric
Examples of Type	Casein, blood albumin, hide, bone, fish, starch (plain and modified); rosin, shellac, asphalt; inorganic (sodium silicate, litharge-glycerin)	Polyvinyl acetate, polyvinyl alcohol, acrylic, cellulose nitrate, asphalt, oleoresin	Phenolic, resorcinol, phenol-resorcinol, epoxy, urea, melamine, alkyd	Natural rubber, reclaim rubber, butadiene-styrene (GR-S), neoprene, acrylonitrile-butadiene (Buna-N), silicone
Most Used Form	Liquid, powder	Liquid, some dry film	Liquid, but all forms common	Liquid, some tape
Common Further Classifications	By vehicle (water emulsion is most common but many types are solvent dispersions)	By vehicle (most are solvent dispersions or water emulsions)	By bonding requirements (heat and/or pressure most common but some are catalyst types)	By bonding req (all are common). Also by vehicle (most are solvent dispersions or water emulsions)
Bond Characteristics	Wide range, but generally low strength; good res to heat, chemicals	Good to 150–200 F; poor creep strength; fair peel strength	Good to 200–500 F; good creep strength; fair peel strength	Good to 150–400 F; never melt completely; low strength; high flexibility
Major Type of Use	Household, general purpose, quick set, long shelf life	Unstressed joints; designs with caps, overlaps, stiffeners	Stressed joints at slightly elevated temp	Unstressed joints on lightweight materials; joints in flexure
Materials Most Commonly Bonded	Wood (furniture), paper, cork, liners, packaging (food), textiles, some metals and plastics. Industrial uses giving way to newer types, esp in woodworking	Formulation range covers all materials, but emphasis on nonmetallics, esp wood, leather, cork, paper, etc., because these are less likely to require stressed joints	Depends greatly on specific type: epoxies for dissimilar materials and plastics; phenolics for metal, glass and wood; ureas and melamines extensively for wood; alkyds for metal laminations.	Few used "straight" for wood, rubber, fabric, foil, paper, leather, plastics films; also as tapes. Most modified with synthetic resins

2—CLASSIFIED BY BONDING TYPE[a]

General Type ⬇	Specific Types Available[b]	Forms Used	Remarks
Heat	Rm temp to 450-F types available; 250 to 350-F types most common	Formulated in all forms; liquid most common	Applying heat will usually increase the bond strength of any adhesive, even rm temp types
Pressure	Contact to 500-psi types available; 25 to 200-psi types most common	Formulated in all forms; liquid + powder most common	Pressure types usually have greater strength (not true of modified epoxies)
Time	Types requiring a few seconds to a week available; ½ to 24-hr types most common	Formulated in all forms	Time required varies with pressure and temp applied and immediate strength
Catalyst	Extremely varied in terms of chemical catalyst required; may also contain thinners, etc.	Two components—paste (or liquid) + liquid	Sometimes catalyst types may require elevated temp (<212 F) and/or pressure instead of, or in addition to, a chemical agent
Vulcanizing	Varied types requiring addition of a chemical agent (usually sulfur); may also contain a catalyst	Two liquid components	Premixed types requiring 250 to 350 F for vulcanization are available
Reactivation	Types requiring heat or solvent or second coating of adhesive	Dry film or previously applied liquid	Heat type is best for nonporous surfaces and/or max strength

[a] Formulations may be a combination of two or more of these types.

[b] Types stated as being most common refer to modified or "alloy" adhesive compounds.

4. **Assembly**—Accomplished during tack life of adhesive (5 min to 1 hr for porous surfaces, but can be extended) or after reactivating dried coating.

5. **Bond development**—Drying out of the solvent usually takes 1 to 60 min. Heat can be applied by warm air, infrared lamps or hot plate; pressure by

Adhesives

3—CLASSIFIED BY VEHICLE[a]

Type ➡	Solvent Dispersion	Water Emulsion	100% Reactive ("100% solids")
Form	Liquids, pastes, tapes, supported films	Liquids	Pastes, films
Adhesive Alloy	Elastomer (rubber or vinyl butyral) + thermosetting resin (phenolic, sometimes epoxy or alkyd)	Reclaimed rubber + asphalt; milk latex	Usually modified epoxies (others for films)
Bonding Requirements	Usually pressure and/or heat, solvents (reactivation type)	Heat and/or pressure	Contact pressure; choice of rm temp or heat curing
Advantages	Flowability; easy to apply in film or tape form and from dispensing bottles. Can be reactivated after drying. Allows widest choice to formulator	Most inexpensive of the three. Eliminates fire hazard. Consistency can be varied by adding water	No time wait for solvent release. Eliminates fire hazard. No attack on vulnerable adherends. High heat resistance. Fills voids
Limitations	Care must be taken to allow for solvent release if both surfaces are nonporous (not usually recommended). Solvent may interact unfavorably with certain plastics	Usually limited to bonding where at least one surface is nonporous. Some types require high pressure. Freezing damages bonding properties	Peel, stretch and impact properties not usually as high as in others. Not freely flowing. Usually supplied as two-component adhesive requiring mixing. High shear strength falls rapidly above specified temp
Remarks	Elastomer adds flexibility, peel and impact strength	Curing characteristics highly influenced by added modifiers	Highly suited for metal-to-metal bonds, electrical uses

[a] This method of classification is the most common for modified compounds, but omits "contact-bond" and "pressure-sensitive" adhesives. Contact-bond adhesives adhere to themselves for a specified period of time after the coating has dried. Pressure-sensitive types adhere to almost any surface for an almost indefinite period of time after drying.

4—CLASSIFIED BY FORM

Type ⬇	Remarks	Advantages
Liquid	Most common form; practically every formulation available. Principally solvent-dispersed	Easy to apply. Viscosity often under control of user. Major form for hand application
Paste	Wide range of consistencies. Limited formulations; principally 100% solids modified epoxies	Lends itself to high production set-ups because of less time wait High shear and creep strengths
Powder	Require mixing or heating to activate curing	Longer shelf life; mixed in quantities needed
Mastic	Applied with trowel	Void-filling, nonflowing
Film, tape	Limited to flat surfaces, wide range of curing ease	Quick and easy application. No waste or run-over; uniform thickness
Other	Rods, supported tapes, precoated copper for printed circuits, etc.	Ease of application and cure for particular use

weighted hand rollers, metal weights or squeeze rolls. With nonporous surfaces, solvent must be dried out before final assembly pressure; for such application heat reactivation types are often used (applying heat and/or pressure after assembly of dried coated parts), but stronger bonds are developed by using 100%-reactive adhesives rather than solvent-dispersed.

5—CLASSIFIED BY FLOWABILITY[a]

Type ⬇	Form or Vehicle Type	Advantages
Flow	Liquid, light or heated pastes, solvent dispersion, water emulsion	Fills crevices, fills complex joints, evens glue line, smooths surface
Nonflow	Heavy paste, trowelable mastic, void-filling epoxy, 100% solids	Applies vertically, requires no "clean-up," fills voids and gaps, does not sag

[a] There is no fine line of distinction between these types. In addition, flowability is affected by such factors as: temperature, pressure, joint design, time left standing, mixing of catalysts or solvents.

Joint Design

Joints should be designed to keep the adhesive in shear and avoid cleavage and peel stresses. Typical good joint designs are shown by the accompanying sketches.

The type of strength under consideration (particularly peel vs shear) is extremely important in adhesive bonding.

Joint properties are also a function of the thickness of the glue line. Shear and creep strength are highest for thin films (0.001 to 0.003 in.), but heavier films may exhibit higher flexibility, toughness and cleavage strength.

Because there are so many factors involved in adhesive selection, compromise may be necessary. To aid the formulator in making this compromise, and to minimize cost, safety factors included in specifications should be only as high as absolutely necessary.

Mechanical Fasteners

Mechanical fastening is the most versatile and most widely used method for joining materials and parts. In the broadest sense, mechanical fasteners can be classified in two groups: threaded types (semipermanent) and rivets (permanent).

Threaded Fasteners

Types. The accompanying table describes the most common types of threaded fasteners (including washers). Some other types include:

Screws—In addition to variations (e.g., spanner heads, wing heads, split points), of every screw described, there are many special types, such as: sealing, twin head, one-way set and load-indicating.

Bolts—Many special head variations are available for the bolts described. Two important types not listed are sealing bolts (designed with an integral rubber washer under the head) and blind bolts (expander nut pulled back into sleeve by hydraulic gun, then core bolt inserted). Still more specialized bolts include: track, blow, tap, bent, load-indicating, crating, rib, and drive and locking stud bolts.

Nuts—There are nuts to mate with almost every type of bolt described. Other types include: acorn, anchor, clinch weldments (attached by spot welding), roofing, wing or thumb, and grommets.

Washers—Special types include: countersunk, sealing, sleeve, load-indicating, pipe and laminated.

Thread series. Most common threads are designated "Unified and American" and are either "coarse" or "fine," depending on the number of threads per inch for a specific diameter. The coarse series is for general use where quick assembly is desired; the fine series for aeronautical and similar work. Other series (e.g., 8-thread), as well as other standards (e.g., Whitworth), are in use.

Thread class. Class refers to the tolerance in manufacture and to the allowances permissible. The majority of screws and bolts are produced to class 2A (external tolerances and positive allowances); nuts to 2B (internal tolerances). Where closeness of fit is required, classes 3A and 3B may be used. Various fits are obtained by combining male and female threads of different classes.

Materials. Although the use of low carbon steel is widespread, all common metals, as well as some thermoplastics, are used in critical applications. To obviate galvanic corrosion, it is often desirable to use fasteners made from a material similar to those being joined. However, the corrosive effect must be weighed against such factors as increased strength and greater holding power.

Screws—Carbon and stainless steels, brass, silicon bronze and aluminum are often standard or available on order. Special materials available in limited types include die cast zinc alloys and several thermoplastics (nylon is most common). Zinc and cadmium-plated screws are often standard, and other electroplates are available on order. Other finishes and coatings include anodized, carbonized and black oxide.

Bolts and nuts—Carbon, alloy and stainless steels are standard for almost every type, but brass, naval bronze, monel and aluminum are often standard as well. Special materials available in some types include: malleable iron, silicon bronze, titanium, sintered brass, nylon and other thermoplastics. Finishes and coatings include those available for screws. Nuts, however, are often supplied with one of the following additional finishes: nickel and silver-plated, molybdenum disulfide, chromate, phosphate, and chromium oxide diffusion.

Washers—Most standard nut materials are also used for washers. Special materials include chromium-molybdenum steel, galvanized steel, vulcanized fibre and extruded nylon. Sealing washers generally are rubber—natural, silicone, neoprene or nitrile. Standard electroplated finish is usually cadmium, but zinc, nickel, tin, copper and chromium are not uncommon. Other finishes include phosphate and oil.

Design. Details of design depend upon many factors, including the type, style and material of the fastener which has been selected after consideration of end service conditions, materials being joined, speed and ease of assembly required, and ease and frequency of disassembly required. Loading should be in shear rather than tension. When assembly of the fastener requires that pressure, sharp blows or torque be applied to one side of the joint, that side should be the one having the thicker or harder material.

Descriptive nomenclature. Threaded fasteners are available with many types of shanks, heads, locking devices, etc.—some standardized and many not—which makes it impractical to define the hundreds of terms used. In addition, fastener terminology is apt to be overlapping, making it difficult, in theory, to distinguish between such items as bolts and screws, or machine screws and certain cap screws. Recent standards, for instance, include stove bolts with machine screws.

In the accompanying tables types have been distinguished according to general practice, rather than theory, as much as possible. In addition, the word "top" has been coined. Industry uses the word "head" for two purposes: to refer to the shape (generally as viewed from the side), and to refer to the design for a particular tool (generally recognizable by viewing from the top). The word "top" used in the tables refers to the latter. For example, a slotted round head (round as viewed from the top and slotted on top for a conventional screwdriver) is listed here as: top—slotted, head—round.

Rivets

Riveting is the fastest production fastening method of producing fairly strong joints with unskilled labor, yet with a high degree of consistency. Rivets are driven either hot or cold, by hammering or peening or by applying steady pressure from one or both sides. The shear strength of solid rivet joints is equal to or higher than that of most common threaded fasteners. Tubular and split are lower in strength, particularly tensile.

Design factors are similar to those for threaded fasteners. Joints are either lap or butt (using butt strap). Minimum recommended rivet spacing is usually three times the body diameter of the rivet. Allowable distances from edges are usually based on the rivet body diameter; 1½D for hot-driven rivets and 2D for cold-driven.

Materials from which rivets are fabricated include iron, low carbon steel, stainless steel, brass, copper, monel, aluminum, nickel silver and several thermoplastics. Coatings and finishes of all types can be ordered.

The table on p 453 describes the most common types of rivets.

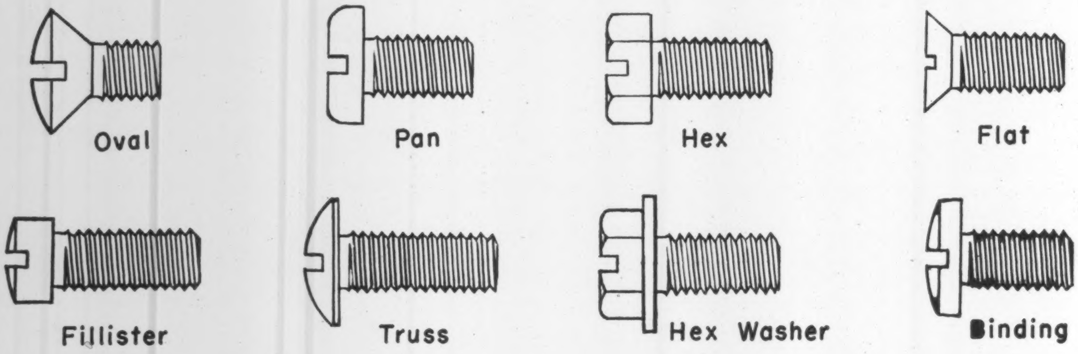
tables start on next page

Mechanical Fasteners

THREADED FASTENERS

Type ⬇	Description	Made of . . .	Selection Features	Uses
SCREWS				
Wood	Top—slotted or cross-recessed. Head—flat, round or oval. Thread—single, some double; point—gimlet. Also drive screws, hanger bolts, dowel screws	Low and medium carbon steels; alloy and stainless steel, monel, others	General use	Wood, and thin sheets of other material to wood
Cap	Top—hex or fluted socket; head—smooth or knurled. Top—slotted; head—round, flat, fillister or hex. Thread—coarse or fine; 8-thread; point-chamfer. Also top—plain; head—hex or knurled	Carbon and stainless steel, brass, bronze, monel, aluminum	General use with tapped holes or nuts. Shank usually not fully threaded. Socket type (most used) has closer fit than machine screws	Fastening metal parts and components
Machine	Top—slotted or cross-recessed; head—round, flat, oval, undercut (flat or oval), fillister, truss, binding or pan. Also hex heads, tops plain or slotted. Thread—coarse or fine; point—sheared	Carbon and stainless steel, brass, silicon bronze, monel, aluminum	Same as cap, but usually full-thread shank and smaller dia. Slotted type most used, generally with nut	Same as cap
Tapping (thread-forming)	ASA "A": Top—slotted or recessed; head—flat, oval, round, pan, fillister, truss or hex; thread—spaced; point—gimlet. "B": Same but blunt point. "BP": Same but cone point. "C": Same but blunt tapered point and machine thread	Case hardened steel; others on special order	A—general sheet metal screw; B—heavier duty; BP—misaligned parts; C—higher strength	All—Sheet metal, wood, asbestos, cloth to sheet metal. C—Cast iron, zinc die castings, steel, bronze and brass forgings, plastics
	Drive screws. 1) Top—plain; head—round; point—dog; thread—multiple with large helix angle. 2) Top—plain; head—pan; point—cone; thread—annular in upper section, but lower section has multiple threads with large helix angle	Case hardened steel; others on special order	Forms mating thread as hammered or pressed; can be applied with hopper-fed machines	Permanent fastenings. 1) Castings, heavy-gage sheet, plastics. 2) Fabric, leather or fiber to sheet metal
Thread-Cutting	ASA "D", "F", "G" and "T": Top—slotted or recessed; head—flat, oval, round, pan, truss or hex; thread—machine; point—blunt. Types differ in cutting edge: D—one off-center slot; F—several flutes; C—one centered through-slot; T—one wide slot. ASA "BF", "BG" and "BT" similar to F, G and T, respectively, but have spaced thread	Case hardened steel; stainless steel on special order	Minimum driving torque; fewer chips; increased resistance to stripping out	As above, but thin sections, particularly bosses in brittle plastics, plywood
Lock	Various proprietary types, such as: 1) preassembled lead washer; 2) variation of A.N. thread form; 3) longitudinal insert; 4) nylon pellet insert; and 5) annular expansion insert. Other types include: preassembled screw and lock washer, screw with locking teeth under head, slotted head fitting into counterbored hole with insert forced into slot. Also, liquid sealants used with standard screws	1—Heat treated alloy steel. 2—All std screw mtls. 3—Steel (incl stainless), brass, aluminum; insert is fluorocarbon plastic. 4—Carbon and stainless steel, aluminum alloy, brass, bronze. 5—Heat treated alloy steel; insert is bronze	1—Washer extrudes around tapered head. 2—Locks on full length of thread by reforming mating thread. 3—Insert does not project, has gradual torque build-up. 4—Insert projects slightly, locks whether or not screw is seated. 5—Insert expands when compressed, remains when screw is removed	Widely used, esp in mass production. Various types allow joining all metals and many plastics. Particular use depends on such factors as: permanent or disassembly; ease of assembly; amount of torque to assemble or disassemble; type of stress—rotational, vibration, thermal; sealing properties

MACHINE SCREW HEADS



Oval

Pan

Hex

Flat

Fillister

Truss

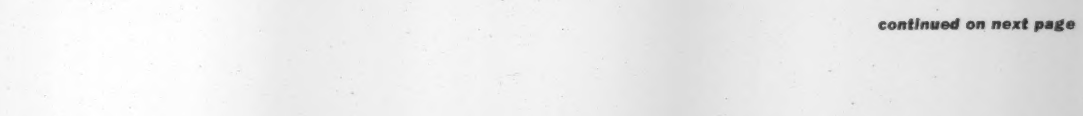
Hex Washer

Binding

THREADED FASTENERS—continued

Type ↓	Description	Made of . . .	Selection Features	Uses
BOLTS AND NUTS				
Regular (general use)	External hexagon or square head, generally used with nut of same shape. "Regular"—unfinished (not machined on any surface except threads); coarse threads. "Regular semifinished"—bolt heads and nuts are machined on bearing surface to provide washer face (or nuts may have chamfered corners); coarse threads. "Finished"—same as regular semifinished but closer body tolerance; threads—coarse, fine and 8-thread. Std machine screw nut is "regular", but has smaller diameter holes	Carbon and alloy steel, stainless steel, brass, naval bronze, monel, aluminum	Longer bolts are similar to hexagon cap screws, shorter to hexagon machine screws, but the hex head is more common with bolts, as is the use of nuts. Bolts come in greater standard lengths, are sturdier (larger body diameter and head height), and are classified in a different manner. Also, unlike screws, the bolt head is usually held while the nut is turned	Widely used for all materials. For larger parts and greater stresses than screws. Where material too soft or hard, or too thin, to be tapped. Where threaded shanks easily accessible
Heavy (heavy duty)	As above, but bolt heads and nuts are thicker and also wider across flats. Minimum standard bolt length is longer Types are: Heavy (unfinished), Heavy Semifinished and Heavy Finished	Same as above		As above, but where more strength is required, or where holes have larger clearances, or where greater length required
Jam Nut	Similar to Regular or Heavy, but thinner	Same as above	Higher shear str; lower ten str than above	Often used with full nut for locking action
Lag Bolt	Head—square; point—gimlet or cone. Also known as lag screw	Low carbon steel	—	Fasten wood together or any material to masonry
Round Head Bolt	Two body styles (std dia and undersized) with coarse threads. Bolts include: 1) round head, square neck; 2) round head, short square neck; 3) round head, ribbed neck; 4) round head, fin neck; 5) 114-deg-countersunk square neck; 6) round head; 7) elevator (flat, large dia head; square neck); 8) ribbed head—slotted and unslotted; 9) step (like elevator but round head); 10) countersunk	Carbon and alloy steel, stainless steel, brass, naval bronze, monel, aluminum	These bolts differ in the method used to prevent rotation during bolting. Each is inserted in a hole which mates with the neck. Head types are selected by appearance or need for flush tops	For 1) wood, 2) steel, 3) hard wood and plastics, 4) wood, 5) wood, 6) any material where there is no other way to prevent rotation, 7) soft materials, 8) flooring, 9) resilient materials to steel, 10) metal to wood
Stud Bolt (stud)	A stud is a rod threaded either completely or on both ends. Types include: tap end (one end to produce interference fit in tapped hole, other for nut); double end (both ends for nuts); continuous thread; hanger bolt (one end has lag screw thread)	Low carbon steel	Advantageous where length adjustment desirable	Widely used for castings (permanently assembled) and for soft metal and plastic parts
Place Bolt	Flexible zone is formed by slotted segments in the upper face of a hex bolt head and a circular recess in the lower face, providing a controlled spring action which increases elastic elongation. Same principle applied to cap screws	Carbon and alloy steel; others available	Provides resistance to loosening by vibration and minimizes fatigue failure. Used with and without nuts	Cylinder heads, flywheel housings, bearings (cap screw), connecting rods
Locknut	Huge variety of proprietary locknuts, most of which can be classified as one of the following types: 1) free-spinning (no locking action until seating begins, e.g., integral toothed washers), 2) prevailing torque (locking depends on some form of interference between male and female threads, e.g., deforming threads or forcing lead or angle), 3) spring action (designed to take advantage of natural spring of the material or with auxiliary springs, e.g., slotted segments; arched base with prongs to lock against threads)	Nuts—carbon steel generally std; also stainless, brass, monel, aluminum. Springs—heat treated spring steel usually std; also stainless, brass, phosphor bronze, beryllium copper. Inserts—bronze usually std; also brass, aluminum, steel	Locknuts remain tight under vibration and replace the use of wire or cotter pins in a hole drilled through bolt and nut. Each type designed for specific use in terms of materials, end service conditions, ease of assembly, etc.	Mass produced automobiles, appliances, machinery, aircraft, furniture, toys, etc.

ROUND HEAD BOLTS



Round Head

Ribbed Neck

Fin Neck

Square Neck

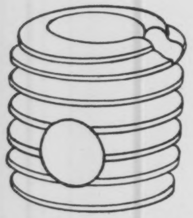
continued on next page

Mechanical Fasteners

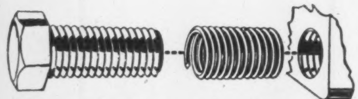
THREADED FASTENERS—concluded

Type ↓	Description	Made of ...	Selection Features	Uses
WASHERS AND INSERTS				
Plain Washer	Plain, flat, circular washer standardized in o.d. and i.d. dimensions (ASAB27.2–1953) and with suggested thicknesses. Form series are: light, medium, heavy, extra heavy	Almost all materials used for nuts	Provide increased bearing surface for bolt heads or nuts, thus distributing load over larger area. Also prevent marring, improve appearance	Widely used with nuts and bolts
Lock Washer	Split spring type. Washer is split and shaped like a single turn of a slight helix. Free height is about twice the washer thickness; gap is small enough to prevent entangling. Same four series as plain washers	Carbon steel, stainless 302 or 420, aluminum-zinc alloy, phosphor and silicon bronze, K monel. Not all materials in all four series	Prevents loosening of bolt under vibration. Split-spring type allows occasional disassembly and reassembly; tang of helix may mar work surface	Widely used for most plain threaded screws and bolts
	Tooth type. Teeth on i.d., o.d. or both. Variety of shapes and tooth types designed for specific uses	Carbon steel, phosphor bronze	Same as above, but thinner than split-spring, not recommended for frequent disassembly	External tooth type for bolts; internal tooth type for screws
	Spring type. Some proprietary types: domed, conical, waved, countersunk, cap, folded rim, tab, irregular hole, wood spring	Medium carbon and stainless steel, bronze, aluminum, beryllium, copper, K monel	Provides strong locking with varied other features	Special uses, generally on softer materials
Insert	May be threaded bushings, studs, etc., cast or molded integrally with part. Many proprietary inserts are molded in or inserted after part is formed. Noncircular cross sections resist turning; undercuts resist tensile pull. Some types are: 1) slotted body, exterior fins, 2) slotted and tapered body containing four-eared disk below threaded portion, 3) spool-shaped spacer, 4) helical coil of diamond-shaped wire (also locking type with center loop of coil octagon-shaped), 5) disk-shaped with edge groove around middle, 6) threaded, with embedded nylon pellet, 7) two-piece: threaded insert and lock ring	1) Aluminum alloy, 2) brass, 3) aluminum alloy, 4) stainless, phosphor bronze, Hastelloy C, 5) brass, steel, stainless, aluminum, 6) low carbon steel, 7) low carbon steel. Most inserts can be obtained in other materials, e.g., brass, bronze, aluminum, monel	Added strength for soft materials. 1) Allows expansion pressure against hole and screw. 2) Disk is forced down to spread four tapered segments. 3) Through-bolt or threaded. 4) Coil has both internal and external thread; inserted in tapped hole. 5) Locked by swaging tool. 6) Uses standard screwdriver. 7) Outer teeth of lock ring broach into parent material	Limited to parts thick enough to hold insert. 1) Wood, plastics, soft metals. 2) Replace molded-in inserts. 3) Sandwich panels. 4) Where weight and wear are problems; used in damaged tapped holes. 5) Plastics sheet, soft sheet metal. 6) Nonferrous metals. 7) Hard materials (resists vibration and stress); soft materials (resists wear)

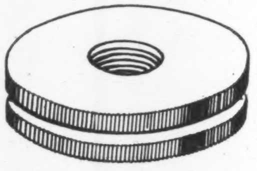
INSERTS



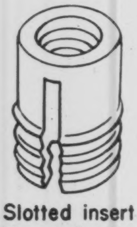
Threaded insert with embedded nylon pellet



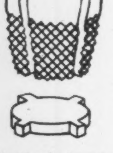
Screw-threaded insert formed by coil of diamond-shaped wire



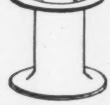
Disk-shaped insert with groove around middle



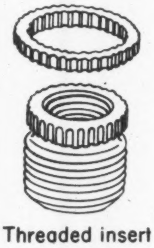
Slotted insert with exterior fins



Slotted, tapered, semi-threaded insert containing four-eared disk



Spool-shaped spacer

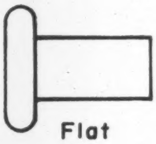


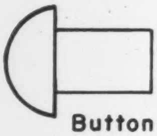
Threaded insert and lock ring

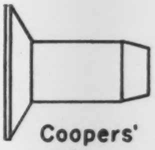
RIVETS, STITCHING AND STAPLING

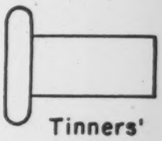
Type ↓	Description	Uses
RIVETS		
Large Solid	Dia from ½–1¾ in. Head—button, high button, cone, pan or countersunk (flat or round). Neck—straight or swell (exc countersunk). Special heads include: machine, globe, wheel, trunk. Wrought iron and steel are std mtls; others available	High production, permanent assembly operations requiring high tensile and shear strength and generally not requiring airtight or watertight joints. Aircraft, ships, trains, bus and truck bodies, etc.
Small Solid	Head—flat, countersunk, button, pan, truss, tinners', coopers' or belt	As above (generally cold riveting is used on small rivets, hot riveting on large)
Semi-Tubular	Shallow hole, extruded or drilled in shanks, does not exceed shank dia. Variety of heads include: oval, flat countersunk, tinners', cone	Where stress is low, or primarily shear. Metals, ceramics, hard plastics and woods; through predrilled or prepunched holes. Aircraft, cameras, toys
Tubular	Hole in shank is deeper than dia but less than ½ in. Rivet compresses material within shank. Head variety same as above	Where stress is low, or primarily shear. Leather, soft plastics, rubber, soft woods, fabrics. Leather cases, golf bags, sheet metal
Split	Slot milled in shank forms two sharp prongs that pierce material without weakening it	Where stress is low, or primarily shear. Light-gage metal, plastics, wood, fibreboard, leather
Shouldered	Shoulder beneath head is made to spec. Either coldformed or coldheaded and turned	Where pivot or bearing surface req within joined members. Automotive parts, vending machines
Blind	Proprietary types, of which most are one of these: 1) sleeve—either hollow (mandrel pulled back through; may be plugged if desired), or self-plugging (after mandrel is pulled through it is trimmed off to leave solid rivet); 2) pin driven through tapered hole in rivet to expand it, then lip peened over pin head; 3) type for which a special assembly tool is basic, e.g., a gun grips pull-through mandrel, clinches rivet, continues to pull until head or stem breaks; 4) explosive charge contained within shank is detonated (by riveting iron, etc.) to expand rivet to fill hole and form bulb on end. Materials are: cadmium-plated steel, aluminum alloy, brass, stainless, monel, etc.	Where backing up the rivet is impractical, usually due to inaccessibility. 1) Lends itself esp to automatic setting; hollow is not as strong but can be plugged by any mtl desired and with umbrella head to match design. 2) High shear str, good ten str. 3) High assembly rate; rivet has high str clinch but is not completely hole-filling. 4) Extremely high assembly rate; widely used to fasten both metals and nonmetallics; nearly equiv in str to solid rivet
Other	Some special rivets are: outside prong, compression, decorative spot, precious metal, brake lining	Special uses
METAL STITCHING AND OTHER FASTENERS		
Stitching and Stapling	Joining two or more materials with 18-gage wire fed from a coil, cut to length, formed, driven through and clinched. High assembly rate, but limited to thin parts, e.g., joining 0.093-in. aluminum strips. Loop clinches are best for nonstructural joints, flat clinches for stressed. Stapling differs in using preformed fasteners. Std mtls include high carbon steel, stainless, and phosphor bronze	For sheet and strip stock of all materials, but preferably joining soft nonmetallics to metal Also sandwich materials
Other Fasteners	Nails, spring clips, retaining rings, pins (straight, dowel, taper, clevis, cotter), quick-release fasteners (snap slides, hinges, hooks, latches), hose clamps, turnbuckles, masonry anchoring devices, vacuum tube retainers, etc.	Special uses

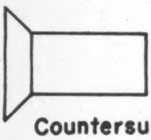
SMALL SOLID RIVET HEADS

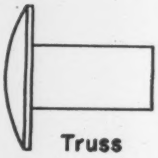

Flat

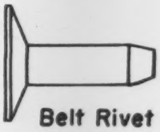

Button

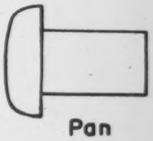

Coopers' Rivet


Tinners' Rivet


Countersunk


Truss


Belt Rivet


Pan

Characteristics of typical Raybestos-Manhattan Ray-BOND® Adhesives

NUMBER	TYPE	CHARACTERISTICS	USES
R-81001 R-81002 R-81114	Thermosetting synthetic rubber, synthetic resin; heat setting. Solids range from 18 to 34%.	Flexible, resistant to oils, solvents; requires heat and pressure for cure.	For bonding metals, plastics, friction materials to themselves or to each other. Not recommended for use on assemblies where bond line temp. might exceed 400°F for prolonged periods in application.
R-82004	Synthetic rubber, synthetic resin; emulsion adhesive; cold setting; solvent evaporation type.	Flexible, good peel strength, medium drying; gains strength upon loss of solvent; exhibits good strength up to 270°F for nonstructural applications.	General purpose adhesive for nonstructural parts.
R-82005 R-82006 R-82007 R-82008	Synthetic rubber, synthetic resin; solvent evaporation type. Solids range from 17 to 30%.	Flexible, good peel strength, quick drying; gains strength upon loss of solvent; not to be used on parts that might be subjected to temperatures in excess of 180°F; sprays well.	General purpose adhesive for nonstructural parts.
R-84001	Synthetic resin; hot melt type.	Flexible, to be heated to 250-300°F and applied. Strength obtained upon cooling.	General purpose adhesive for bonding most materials including mylar and polyethylene. Recommended as a nonstructural adhesive for applications where the bond line temperature will not exceed 150°F.
R-84029	Synthetic resin; heat setting.	Heat resistant to 650°F; some degree of flexibility; resistant to oils, solvent, water, brake fluids.	Friction material to friction material or to steel where some degree of flexibility is desired.
R-86005	Synthetic resin; 2-component system.	High tensile strength, room temperature curing; salt spray, hydraulic oil, JP-4 fuel resistant.	Metal-metal, ceramic-metal, glass-metal.
R-86008	Synthetic resin; 2-component system.	Good electrical properties, low shrinkage. Heat distortion point of 178°F. Pot life 30 min.	Casting, encapsulating and potting. Metal-metal, ceramic-metal, glass-metal.
R-86044	Special synthetic resin base; 2-component system.	Room temp. curing; 40 min. working life.	Bonding etched Teflon to metal, glass to glass, where optimum chemical resistance is desired.
R-87001	Synthetic rubber base.	Good adhesion; high peel strength up to 270°F; contains no flammable solvents.	Fabrics to fabrics.
R-86020	Special synthetic resin; single component system.	High tensile strength; excellent resistance to most chemical acids and alkalies. Heat resistant to 400°F; unlimited pot life.	Metal-metal, ceramic-metal, metal-plastics.

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1. Heat setting, synthetic resin adhesives, coatings, and sealers (not epoxy)
2. Cold setting, synthetic resin adhesives (not epoxy)
3. Heat setting, synthetic resin, synthetic rubber adhesives
4. Cold setting, synthetic resin, synthetic rubber adhesives
5. Rubber base adhesives
6. Synthetic resin sealants, and coatings (not epoxy)
7. Epoxy base adhesives, coatings and sealers; casting, encapsulating and potting compounds

Experienced Raybestos-Manhattan technicians will give you the benefits of more than 20 years of experience in the production of bonded assemblies and the manufacture of adhesives, coatings and sealers. They will provide you with full technical information and recommendations on the latest methods proved most efficient in many successful applications. Why not call on Raybestos-Manhattan engineers today to cut costs or improve production in your operations.

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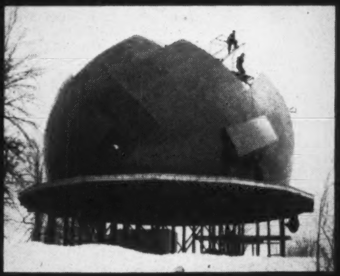
stitching together a giant radome



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Radar antennae along the upper perimeter of North America's defense system are enclosed by protective domes which stop ice, snow, and gales up to 150 mph.

This precisely engineered pattern of fiberglass panels is erected quickly and surely, under the most adverse field conditions, using recessed Simmons DUAL-LOCK fasteners.

DUAL-LOCK is ideally adapted to panel fastening for military shelters, demountable shipping containers, aircraft cowlings and guided missiles.

Features:

- High load characteristics. The standard No. 1 DUAL-LOCK withstands 2500-lb. tension, and with modifications, tension loads of 7000 lbs. and over.
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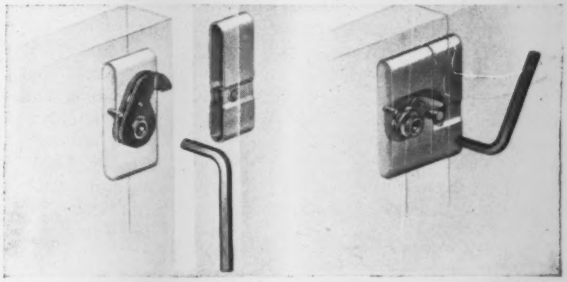
- Positive-locking. Trigger action insures fully open and fully closed positions.
- Vibration-proof and impact-proof. Will not accidentally unlock or loosen.

Write for catalog #1257. Complete specifications, drawings, details of DUAL-LOCK and other Simmons Fasteners with unlimited money-saving applications.



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No. 3 of a series

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910
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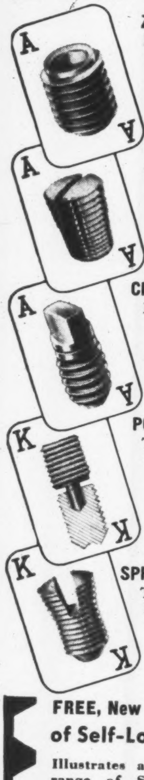

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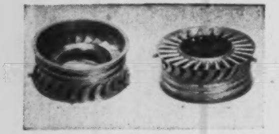

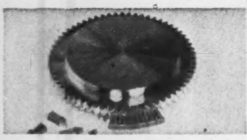

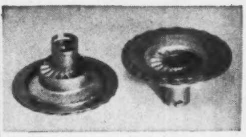

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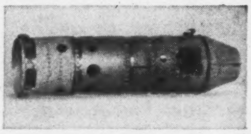

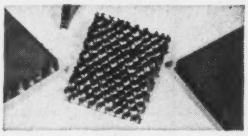

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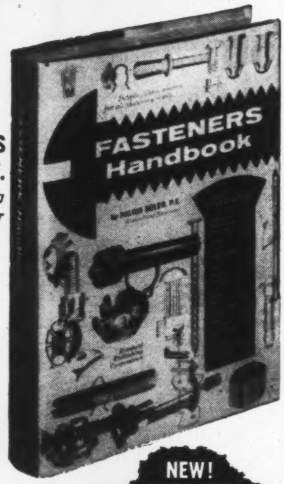

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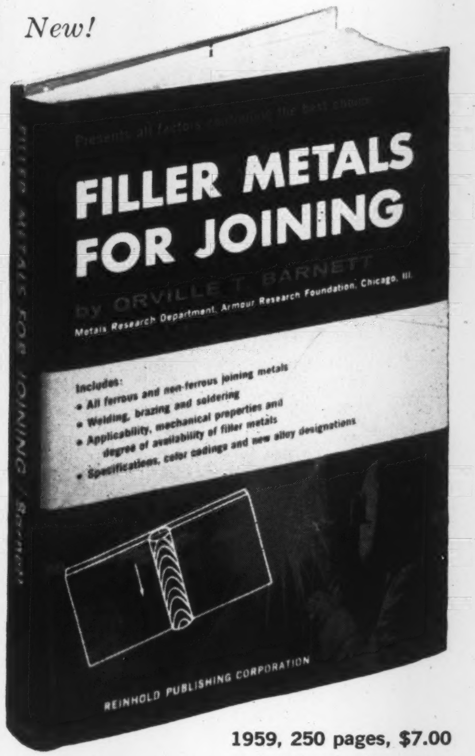
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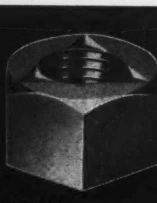
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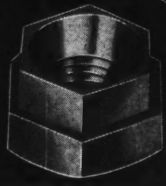
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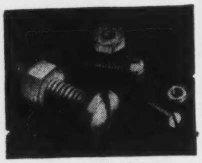

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Directory Section

Suppliers of Materials

Addresses of Suppliers

Suppliers of Materials

Addresses of Suppliers

THE DIRECTORY

This Directory is designed to be a comprehensive and up-to-date source of suppliers of engineering materials, forms, finishes and closely related services. The listings were compiled from information received from more than 3000 manufacturers, from official information made available by trade associations, and from many other sources.

HOW TO USE THE DIRECTORY

The Directory consists of two sections. In the first, the categories of materials, forms, finishes and related services are arranged alphabetically; suppliers in each category also are listed alphabetically with their geographical location indicated by state abbreviations. The many cross references make it easy to find any given category. In general, suppliers of basic or "mill" forms of materials, such as sheet, are listed under the particular materials, whereas suppliers of "fabricated" forms, such as forgings, are listed under the form.

Key letters in parenthesis following names of suppliers provide two kinds of additional information: 1) the basic materials in which a supplier furnishes a particular fabricated form, and 2) the basic forms in which a supplier furnishes a particular material (see key at right). For example, if you are looking for suppliers of magnesium sand castings, you will look for those suppliers of sand castings whose names are followed by the letter "e." Similarly, if you are looking for suppliers of cellulose acetate rod, you will look for those suppliers of cellulose acetate whose names are followed by the letters "bb."

Further information on a particular supplier's product can often be found by consulting an advertisement in this issue. Advertisers' names are bold-faced, and the pages on which their advertisements appear are listed following their name in the appropriate category. Page numbers of advertisements are also given in the complete index to advertisers on pp 8-10.

The second part of the Directory contains a complete alphabetical list of suppliers and their addresses. To find the address of a division of a company, look up the name of the parent company (always given with the division name in the first part of the Directory).

In compiling a directory of this nature it is impossible to avoid errors and omissions. We will welcome corrections and suggestions. Please address them to Directory Editor, MATERIALS IN DESIGN ENGINEERING, *430 Park Ave., New York 22, N. Y.*

MATERIALS

a	Aluminum and its alloys
b	Copper and its alloys
c	Iron and its alloys (except steel)
d	Lead and its alloys
e	Magnesium and its alloys
f	Nickel and its alloys
g	Steels
h	Titanium and its alloys
j	Zinc and its alloys
k	Thermoplastics
l	Thermosetting plastics
m	Elastomers

BASIC FORMS

n	Anodes
o	Bar
p	Base resins, polymers or gums
q	Billets
r	Custom formed parts (incl. specialties)
s	Fibers
t	Film
u	Foams (component materials or products)
v	Foil
w	Ingot
x	Laminating, casting resins
y	Molding compounds
z	Plate
aa	Powder
bb	Rod
cc	Sheet
dd	Strip
ee	Tubing
ff	Wire

The listings and other data in this directory are compiled from sources believed reliable by the publisher. The publisher, however, does not represent or guarantee the accuracy of said listings and data, and no responsibility is assumed therefor.

Suppliers of Materials

ABS

(acrylonitrile-butadiene-styrene)

Marbon Chemical Div., Borg-Warner Corp., Ind
(y)—Ad pp 266-267
Naugatuck Chemical Div., U.S. Rubber Co., Conn (y)
U.S. Rubber Co., Footwear Div., Ill
(cc)—Ad p 243

Acetal Plastics

Albany Novelty Mfg. Co., Mass (t,cc)
Anderson Assoc., Inc., Ohio (y)
Bamberger, Claude P., Inc., NJ (y)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Davis, Joseph Plastics Co., NJ (t,y, bb,cc,dd,ee)
du Pont de Nemours, E.I. & Co., Inc., Del
(p,t,x,y)
National Vulcanized Fibre Co., Del
(bb,cc,ee)—Ad p 226
Shawinigan Resins Corp., Mass (p)
Superior Plastics, Inc., Ill (bb,cc,ee)

Acetate

(see Cellulose Acetate)

Acrylate Rubber

(see Acrylic Rubber)

Acrylic Plastics

Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
American Molding Powder & Chemical Co., NY (y)
American Products Mfg. Co., Inc., La (t,bb,cc)
Anchor Plastics Co., Inc., NY (bb,dd, ee)
Anderson Assoc., Inc., Ohio (y)
Artus Corp., NJ (cc,dd)
Auburn Plastic Engineering, Ill (bb, cc,ee)
Auburn Plastics, Inc., NY (bb,dd,ee)
Bamberger, Claude P., Inc., NJ (y)
Blank, Arthur & Co., Inc., Mass (cc)
Borden Co., Borden Chemical Div., NY (p)
Cadillac Plastic & Chemical Co., Mich (p,x,bb,cc,dd,ee)
Carroll Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Cast Optics Corp., NJ (cc)
Chemical Development Corp., Mass (p)
Colonial Kolonite Co., Ill (bb,cc,ee)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Ohio (p)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,dd,ee)
Denver Plastics, Inc., Colo (bb,cc,dd, ee)
Dow Chemical Co., Plastics Div., Mich
(s)
du Pont de Nemours, E.I. & Co., Inc., Del
(p,s,x,y)—Ad p 246
Dura Plastics of New York, Inc., NY (bb,cc.dd,ee)
Durable Formed Products, Inc., NY (cc,ee)
Dyna-Therm Chemical Corp., Calif
(p)
Eljay Corp., Md (bb,cc,dd,ee)
Fluoro-Plastics, Inc., Div. of Flexrock Co., Pa (bb,cc)
Foss Mfg. Co., Plastics Div., Id (cc)
Fry Plastics Co., Calif (bb,cc)
Galigher Co., Utah (bb,cc,dd,ee)
General Aniline & Film Corp., NY (cc)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Gering Products, Inc., NJ (y)
Grigoleit Co., Ill (p,s)
H & R Industries, Pa (bb,cc,dd,ee)
Industrial Plastics Corp., Ind (bb,dd)
Jet Specialties Co., Inc., Calif (bb, dd,ee)
K S H Plastics, Inc., Mo (bb,cc,dd)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc)
Midwest Plastic Products Co., Ill (cc, dd)
Muehlstein, H. & Co., Inc., NY (p, y,cc)
Norrich Plastics Corp., NY (bb,cc,ee)
Perfex Plastics, Inc., Ill (bb,dd)
Philrus Products Co., NJ (bb,cc,dd, ee)
Plast-Ad Mfg. Co., Ind (bb,cc,dd,ee)
Plastic Materials, Inc., NY (y)
Pyramid Industries, Inc., Pa (ee)
Raybestos-Manhattan, Inc., Raybestos Div., Conn (x)
Reed Plastics Corp., Mass (y)
Rohm & Haas Co., Pa
(y,cc)—Ad p 245
Russell Mfg. Co., Conn (s)
Schwab Plastics Corp., Mich (bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Snyder Mfg. Co., Inc., Ohio (cc)
Southern Plastics Co., SC (bb,cc,dd, ee)
Superior Plastics, Inc. Ill (bb,dd)
Union Carbide Corp., Textile Fibers Dept., NY (s)
United Shoe Machinery Corp., Mass (p)
Western Felt Works, Ill
(cc)
Westlake Plastics Co., Pa (t,y,bb,cc, dd,ee)
World Plastics, NY (bb,cc,dd,ee)

Acrylic Rubber

Adhesive Products Corp., NY (x)
Borden Co., Borden Chemical Div., NY (p)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Continental Rubber Works, Pa (bb, cc,dd,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I., & Co., Inc., Del
(cc)
Dyna-Therm Chemical Corp., Calif
(p)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,cc)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Goodrich, B.F. Chemical Co., Ohio (p,cc)
Maloney, F.H. Co., Tex (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Norrich Plastics Corp., NY (bb,cc,dd, ee)
Parker-Hannifin Corp., Parker Seal Div., Ohio (u)
Polymer Chemical Co., Ohio (x)
Roth Rubber Co., Ill
(cc)
Russell Mfg. Co., Conn (s)
Southern Plastics Co., SC (bb,cc,dd,ee)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Wasco Products, Inc., Mass (cc)
Western Felt Works, Ill
(y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill
(y,bb,cc,dd,ee)

Acrylonitrile-Butadiene Rubber

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NY
(bb,cc,dd)—Ad pp 240-241
American Rubber Products Corp., Ind (u,bb,cc,dd,ee)
Anderson Assoc., Inc., Ohio (y)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Borden Co., Borden Chemical Div., NY (p)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Faultless Rubber Co., Ohio (y,bb,ee)
Firestone Tire & Rubber Co., Ohio (p)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,bb,cc,dd, ee)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Chemical Co., Ohio (p, cc)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (p)
Goshen Rubber Co., Inc., Ind
(y)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Lee Rubber & Tire Corp., Republic Rubber Div., Ohio (p,y,cc,dd,ee)
Luzerne Rubber Co., NJ (bb,cc,dd,ee)
Maloney, F.H. Co., Tex (y)
Marbon Chemical Div., Borg-Warner Corp., Ind
(p,x,y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y,cc,dd)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,x,y)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Parker-Hannifin Corp., Parker Seal Div., Ohio (u)
Polymer Chemical Co., Ohio (x)
Prince Rubber Co., Inc., NY (cc,ee)
Raybestos - Manhattan, Inc., Plastic Products Div., Conn
(x)

Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries, Inc., Va (u)
Saran Lined Pipe Co., Mich (y,cc)
Sheller Mfg. Corp., Mich (u)
Southern Plastics Co., SC (bb,cc,dd,ee)
Stockwell Rubber Co., Inc., Pa (y,bb,cc,dd)
Technical Specialties Co., NY (dd)
Toyad Corp., Pa (u)
Trostel, Albert Packings, Ltd.,Wis (y)
U.S. Rubber Co., NY (p)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Westlake Plastics Co., Pa (bb,cc,dd)
Western Felt Works, Ill (y,cc,dd,ee)
Williams - Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Adhesives

(see also Tapes)

Adhesive Products Corp., NY (k,l,m)
Alcylite Plastics & Chemical Corp., Calif (k,l)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (l)
American Cyanamid Co., Plastics & Resins Div., NY (l)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l,m)
American Metaseal Corp., NJ (l)
American Products Mfg. Co., Inc., La (k,m)
American Sealants Co., Conn (l)
Angier Adhesives Div., Interchemical Corp., Mass (k,l,m)
Arabol Mfg. Co., NY (k)
Aries Laboratories, Inc., NY (l)
Armour & Co., Adhesive Div., Ill (k,m)
Armstrong Cork Co., Pa (k,l,m)
Armstrong Products Co., Ind (l)
Atlantic Bag Co., NY (l)
Atlas Mineral Products Co., Pa (k,l,m)
Avery Label Co., Decorative Products Div., Ohio (l)
Avondale Co., Ill (k,l,m)
Babbitt Chemical Co., Inc., Mass (k)
Beck, I. & Sons, Inc., NY (m)
Belding Corticelli Industries, NY (k,l,m)
Belko Corp., Md (m)
Biggs, Carl H. Co., Inc., Calif (k,l)
Bisonite Co., Inc., NY (l)
Borden Co., Borden Chemical Div., NY (k,l,m)
California Metal Enameling Co., Calif (k,m)
Campro Co., Ohio (k)
Capac Mfg. Corp., Mich (k,l,m)
Catalin Corp. of America, NY (l)
Ceilcote Co., Ohio (k,l,m)
Chemical Coatings & Engineering Co., Inc., Pa (k,l,m)
Chemical Development Corp., Mass (k,l)
Chemical Process Co., Calif (l)
Chemical Products Corp., RI (k,m)
Chrysler Corp., Cycleweld Div., Mich (k,l,m)
Ciba Co., Inc., NY (l)
Clinton Co., Ill (k,l,m)
Colonial Kolonite Co., Ill (k)
Connecticut Hard Rubber Co., Conn (m)
Continental Can Co., Conolite Div., Del (l)
Cooper, Peter Corp., NY (k)
Cordo Chemical Corp., Conn (k,l,m)
CrystalX Corp., Pa (k)
Dacar Chemical Products Co., Pa (k,l,m)
Dayton Rubber Co., Ohio (k,l,m)
Dennis Chemical Co., Mo (k,m)
Devcon Corp., Mass (k,l)
Douglas & Sturgess, Calif (l,m)
Dow Corning Corp., Mich (m)
du Pont de Nemours, E.I. & Co., Inc., Del (k)
Durable Formed Products, Inc., NY (k)
Dyna-Therm Chemical Corp., Calif (k,l,m)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., Tenn (k)—Ad p 456
Electro Chemical Engineering & Mfg. Co., Pa (k,l,m)
Emerson & Cuming, Inc., Mass (k,l,m)
Everlite Corp., Wash (k,l,m)
Fanner Mfg. Co., Munray Products Div., Ohio (k)
Flexfirm Products, Calif (k)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Foss Mfg. Co., Plastics Div., Id (l)
Franklin Glue Co., Ohio (k)
Fry Plastics Co., Calif (k,l)
Fuller, H.B. Co., Minn (k,l,m)
Furane Plastics, Inc., Calif (l)
General Electric Co., Silicone Products Dept., NY (k,l)
General Mills, Inc., Chemical Div., Ill (k,l)
General Plastics Mfg. Co., Wash (k,l,m)
Gomar Mfg. Co., Inc., NJ (k)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (k)
Great Lakes Carbon Corp., NY (l)
Hadley Bros.-Uhl Co., Mo (m)
Hardman, H.V. Co., Inc., NJ (l)
Haskelite Mfg. Corp., Mich (k,l,m)
Haveg Industries, Inc., Del (l)
Hayes Adhesive Co., Inc., Mo (k,l)
Houghton Laboratories, Inc., NY (k,l,m)
Hughes Glue Co., Mich (k,l,m)
Industrial Polychemical Service, Calif (k,l,m)
Interchemical Corp., NY (k,l,m)
Interchemical Corp., Finishes Div., NJ (k,l,m)
Jamestown Finishes, NY (k)
Johns-Manville Corp., NY (k,l,m)
Johns-Manville Corp., Dutch Brand Div., Ill (m)
Kendall Co., Polyken Sales Div., Ill (k,l)
Lee Rubber & Tire Corp., Pa (m)
Lord Mfg. Co., Special Products Div., Pa (k,l,m)
Maas & Waldstein Co., NJ (k,l)
Magic Iron Cement Co., Ohio (k)
Magnesium Co. of America, Ind (k,l)
Maloney, F.H. Co., Tex (k,l,m)
Manhattan Adhesives Corp., NY (k,l,m)
Mansol Ceramics Co., NJ (l)
Marblette Corp., NY (l)
Marbon Chemical Div., Borg-Warner Corp., Ind (k,l)
Mesa Plastics Co., Calif (l)
Midland Adhesive & Chemical Corp., Mich (k,l,m)
Minneapolis Honeywell Regulator Co., Minn (l)
Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., Mich (k,l,m)
Miracle Adhesives Corp., NY (k,m)
Monsanto Chemical Co., Plastics Div., Mass (l)
Morningstar-Paisley Inc., NY (k,l,m)
Narmco Resins & Coatings Co., Calif (l,m)
National Casein Co., Ill (k,l)
National Starch Products, Inc., Structural Products Div., NY (k,l,m)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (k,l,m)
Nukem Products Corp., NY (k)
Ohio Adhesives Corp., Ohio (k,l,m)
Parker Paint Mfg. Corp., Ind (k)
Pawling Rubber Corp., NY (k,l)
Pecora, Inc., Pa (k,m)
Permacel, Inc., NJ (k,l,m)
Perry-Austen Mfg. Co., NY (l,m)
Peterson, D.J. Co., Wis (k)
Pierce & Stevens Chemical Corp., NY (k,l,m)
Plast-Ad Mfg. Co., Ind (k,l)
Poly Resins, Calif (l)
Polymer Chemical Co., Ohio (k,l,m)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (k)
Polymer Industries, Inc., Conn (k,l,m)
Presstite - Keystone Engineering Products Co., Mo (k,l,m)
Quelcor, Inc., Pa (l)
Randolph Products Co., NJ (k,l,m)
Raybestos - Manhattan, Inc., Adhesives Div., Conn (k,l,m)—Ad p 455
Reichhold Chemicals, Inc., NY (l)
Ren Plastics, Inc., Mich (l)
Reynolds Aluminum Supply Co., Ga (k,l)
Rohm & Haas Co., Pa (k,l)
Rubber & Asbestos Corp., NJ (k,l,m)
Rubber & Plastics Compound Co., Inc., NY (k)
St. Clair Rubber Co., Mich (m)
Sauereisen Cements Co., Pa (k,l)
Schwartz Chemical Co., Inc., NY (k,l,m)
Shell Chemical Corp., NY (l,m)
Sillcocks Miller Co., NJ (k)
Snyder Mfg. Co., Inc., Ohio (k)
Southern Adhesives Corp., Va (k,l,m)
Standard Insulation Co., NJ (l)
Steelcote Mfg. Co., Mo (l)
Stockwell Rubber Co., Inc., Pa (m)
Superior Plastics, Inc., Ill (k)
Surprenant Mfg. Co., Mass (k)
Synco Resins, Inc., Conn (k,l)
Toyad Corp., Pa (m)
U B S Chemical Corp., Mass (k,l,m)
Union Paste Co., Mass (k,l)
United Shoe Machinery Corp., Mass (k,l,m)
U.S. Stoneware Co., Ohio (k,l)
Waterman Industries, Inc., Calif (k,l)
Western Plastics Corp., Wash (k)
Westlake Plastics Co., Pa (k)
Williamson Adhesives, Inc., Ill (k,l,m)
Youngstown Sheet & Tube Co., Fibercast Div., Okla (l)

Alkyd Plastics

Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,y)
American Cyanamid Co., Plastics & Resins Div., NY (p)
Anderson Assoc., Inc., Ohio (y)
Archer-Daniels-Midland Co., Minn (p)
Dyna-Therm Chemical Corp., Calif (p)
Electrofilm, Inc., Calif (t)
Fiber Glass Industries, Inc., NY (u,x,y,cc)
Foss Mfg. Co., Plastics Div., Id (cc)
General Electric Co., Insulating Materials Dept., NY (p)
Glaskyd, Inc., Ohio (y)
Hays Mfg. Co., Pa (y)
Hercules Powder Co., Inc., Del (p)
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc., Ky (p)
Kurz Kasch, Inc., Ohio (y)
Naugatuck Chemical Div., U.S. Rubber Co., (p,x,y)
Panelyte Div., St. Regis Paper Co., NY (x,y)
Reichhold Chemicals, Inc., NY (p)
Schenectady Varnish Co., Inc., NY (p)
Sherwin-Williams Co., Ohio (p)
Specialty Resins Co., Calif (p)
Westinghouse Electric Corp., Micarta Div., SC (p)

Alloy Steels

(see Steel)

Aluminides

(see Refractories)

Aluminized Metals

(see Precoated Metals)

Aluminizing

(see Immersion Coatings)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Aluminum and Its Alloys

A & A Die Casting Co., Calif (cc)
Acme Tube, Inc., NJ (ee)
Adams Engineering Co., Inc., Fla (q, ee)
Advance Screw Products Co., Inc., Wis (o)
Advance Stamping Co., Mich (dd)
Aerolite Extrusion Co., Ohio (n,o,,bb, dd,ee)
Alabama Wire Co., Inc., Ala (ff)
Albert Pipe Supply Co., Inc., Foundation Div., NY (ee)
Alcasco Foundry, Ill (w)
Alloys & Chemicals Mfg. Co., Inc., Ohio (w,aa)
All-State Welding Alloys Co., Inc., NY (ff)
Alofs Mfg. Co., Mich (cc,dd,ff)
Alpha Metals, Inc., NJ (v)
Aluminium Ltd. Sales, Inc., NY (q,w)
Aluminum Co. of America, Pa (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Aluminum Billets, Inc., Ohio (q)
Aluminum Foils Co., Tenn (v)
American Brass Co., Sub. of Anaconda Co., NY (cc,dd,ee)—Ad p 377
American Nickel Alloy Mfg. Corp., NY (w,aa)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (w)
Anaconda Aluminum Co., Sub. of Anaconda Co., Ky (q,v,w,bb,cc,dd,ee)
Apex Smelting Co., Ill (o,q,w,bb)
Arcos Corp., Pa (ff)
Armet Alloys, Inc., Ohio (w)
Arrow Metal Products Corp., NJ (cc)
Atlantic Steel Co., Ga (o,cc)
Auld, D.L Co., Ohio (o,bb,cc,dd,ff)
Aurora Refining Co., Ill (w)
Babson Dow Mfg. Co., Mass (o)
Badger Aluminum Extrusions, NY (o, q,dd,ee)
Bay State Refining Co., Inc., Mass (w)
Belmont Smelting & Refining Works, Inc., NY (n,w,aa)—Ad p 159
Biddle Screw Products Co., Ind (o, bb,ee)
Bohn Aluminum & Brass Corp., Mich (o,q,bb,ee)
Bonnell, William L. Co., Inc., Ga (bb,ee)
Both, O.A. Corp., Mass (aa)
Bridgeport Brass Co., Conn (o,bb,cc,dd,ee,ff)
Bridgeport Rolling Mills Co., Conn (dd)
Briel Industries, Inc., Ind (q,w)
Brinkerhoff Brass & Bronze Works, Inc., NY (z,bb,cc,dd,ee)
Caspers Tin Plate Co., Ill (cc,dd)
Castle, A.M. & Co., Ill (o,z,cc,dd,ee, ff)
Central Fabricators, Inc., Ohio (z,bb, cc,ee)
Channel Master Corp., NY (q,ee)
Clad-Rex Corp., Ill (cc)
Clark Perforating Co., Mich (cc,dd)
Clarksville Foundry & Machine Works, Tenn (o,w,z,ee)
Cleveland Electro Metals Co., Ohio (w)
Cochran Foil Co., Sub. of Anaconda Co., NY (v,cc,dd,ee)
Commercialores, Inc., SC (aa)
Copper & Brass Sales, Inc., Mich (o, v,z,bb,dd,ee,ff)
Corson Industries, Pa (q,bb,ee)
Craft Metal Spinning Co., Ill (cc)
Dahlin, C.A. Co., Ill (cc,ee)
Designers Metal Corp., Ill (cc)
Dixie Aluminum Corp., Ga (o,bb)
Dormont Mfg. Co., Pa (ee)
Dudek & Bock Spring Mfg. Co., Ill (ff)
Eastern Rolling Mills, Inc., NY (cc,dd)
Edgecomb Steel & Aluminum Corp., NJ (o,z,cc,dd,ee)
Empire Metal Co., NY (o,q,w)
Eynon-Dakin Co., Mich (ee)
Fairmont Aluminum Co., W. Va (cc, dd)
Federated Metals Div., American Smelting and Refining Co., NY (o, w)
Flynn, Michael Mfg. Co., Pa (o,bb,ee)
Foamalum Corp., Ill (foamed)
Foil Div., Reynolds Metals Co., Va (v)
Frasse, Peter A. & Co., Inc., NY (o,z,bb,cc,dd,ee,ff)
Fromson Orban Co., Inc., NY (o,z, bb,cc,dd,ee,ff)
Frontier Bronze Corp., NY (w)
General Cable Corp., NY (ff)
General Extrusions, Inc.,Ohio (o,bb,ee)
General Smelting Co., Pa (w)
Gold Leaf & Metallic Powders, Inc., NY (aa)
Harbot Die Casting Corp., NJ (w)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum Sales, Inc., Calif (o,q,w,bb,ee)
Hayden Wire Works, Inc., Mass (aa)
Hexcel Products, Inc., Calif (v)
Himmel Bros. Co., Conn (o)
Hokin Aluminum Co., Ill (o,bb)
Hommel, O. Co., Pa (aa)
Houston Blow Pipe & Sheet Metal Works, Tex (o,z,cc)
Inshield Die & Stamping Co., Ohio (cc,dd)
Jackson Steel Products, Inc., NY (ee)
Jarl Extrusions, Inc., NY (o,q,bb,ee)
Jelliff, C.O. Mfg. Corp., Conn (ff)
Jobbins, William F., Inc., Ill (w)
Johnston Foil Div., Standard Packaging Corp., Mo (v,cc)
Kaiser Aluminum & Chemical Sales, Inc., Ill (n,o,q,v,w,z,bb,cc,dd,ee,ff)
Kawecki Chemical Co., NY (w)
Kawneer Co., Mich (o,q,z)
Kinkead Industries, Inc., Ill (q,z,cc, dd)
Kirk, Morris P. & Son, Calif (w)
Korhumel Steel & Aluminum Co., Ill (o,z,bb,cc,dd,ee,ff)
Laminated Shim Co., Conn (cc)
Langsenkamp, F.H. Co., Ind (o,z,bb, cc,dd,ee,ff)
Light Metals, Inc., Ind (n)
Lucas-Milhaupt Engineering Co., Wis (dd,ff)
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Magna Mfg. Co., Inc., NJ (aa)
Magnode Products, Inc., Ohio (o)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass. (o,ee)
Malone Bronze Powder Works, Inc., NY (aa)
May, Inc., Tex (o,bb,ee)
McGregor-Michigan Corp., Mich (ee)
Mechanical Steel Tubing Corp., NY (ee)
Metal Forming Corp., Div. of Vanadium-Alloys Steel Co., Ind (ee)
Metal Goods Corp., Mo (o,z,bb,cc,dd, ee,ff)
Metallizing Co. of Los Angeles, Inc., Calif (bb,ff)
Metallizing Engineering Co., Inc., NY (ff)
Metals & Controls Corp., General Plate Div., Mass (v)
Metals Disintegrating Co., Inc., NJ (aa)—Ad p 415
Morrisville Foundry Co., Inc., Vt (bb)
Mueller Brass Co., Mich (bb)—Ad p 397
Murray, A.B. Co., Inc., NJ (ee)
National Aluminum Co., Ohio (bb,ee)
National Lead Co., NY (o,bb,ee)
National U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Nesor Alloy Products Co., NJ (ff)
New Jersey Aluminum Extrusion Co., Inc., NJ (bb,ee)
New Jersey Metals Co., NJ (w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Nuclear Metals, Inc., Mass (bb,dd,ee)
Olds Alloys Co., Calif (ee)
Olin Mathieson Chemical Corp., Aluminum Div., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad p 157
Olin Mathieson Chemical Corp., Metals Div., NY (o,q,w,z,bb,cc,dd,ee)
Ormond Mfg. Co., Inc., NJ (dd,ff)
Penn Extrusion Corp., Pa (ee)
Pioneer Aluminum, Inc., Calif (o,z,bb, cc,ee)
Precision Tube Co., Inc., Pa (ee)
Quaker State Metals Co., Pa (cc)
Reade Mfg. Co., Inc., NJ (aa)
Republic Metals Co., Inc., NY (o,v, w)
Revere Copper & Brass, Inc., NY (o,v, z,bb,cc,dd,ee)
Reynolds Aluminum Supply Co., Ga (o, z,bb,cc,dd,ee,ff)
Reynolds Metals Co., Va (o,q,v,w,z,aa, bb,cc,dd,ee,ff)
Rigidized Metals Corp., NY (cc,dd)
Rodney Metals, Inc., NY (dd)
Roebling's, John A. Sons Corp., NJ (dd,ff)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
Saginaw Bearing Co., Mich (o)
Sall, George Metals Co., Inc., Pa (w)
Scovill Mfg. Co., Mill Products Div., Conn (bb,cc,dd)—Ad pp 165-166
Security Sash & Screen Co., Mich (cc)
Sel-Rex Corp., NJ (n)
Smith-Moon Steel Co., Inc., Kan (o,z,cc)
Sonken-Galamba Corp., Kan (q,w)
Southern Aluminum Finishing Co., Inc., Ga (o,z,bb,cc,dd,ee)
Standard Metals Corp., Mass (ee)
Star Heel Plate Co., Inc., NJ (ff)
Stranahan Foil Co., Inc., NJ (v)
Sun Steel Co., Ill (cc,dd)
Techalloy Co., Inc., Pa (n,dd)
Trim Alloys, Inc., Mass (o,bb,ee)
Ullmann, Inc., Wis (o,ee)
United Screw & Bolt Corp., Ill (bb, cc,dd,ff)
United Smelting & Aluminum Co., Inc., Conn (cc,dd)
U.S. Bronze Powder Works, Inc., NJ (aa)
U.S. Extrusions Corp., NY (bb)
U.S. Gasket & Shim Co., Ohio (v)
U.S. Reduction Co., Ind (w)
United Wire & Supply Corp., RI (ee, ff)
Universal Converting Corp., Mass (o, bb,ee)
Utility Mfg. Co., Mass (bb)
Vanadium Corp. of America, NY (w)
Vulcan Rail & Construction Co., NY (o,z,ee)
Wallace Tube Co., Div. of Wallace Supplies Mfg. Co., Ill (ee)
Warner Mfg. Corp., NJ (o,bb,ee)
Waterman Industries, Inc., Calif (o,bb, cc,dd,ee)
Wells Aluminum Corp., Ind (o,bb,ee)
Werner, R.D. Co., Inc., NY (o,q,w, bb,ee)
White Metal Rolling & Stamping Corp., NY (o,q,bb,ee,ff)
Whitehead Metal Products Co., Inc., NY (o,w,z,bb,cc,dd,ee,ff)
Wilder Mfg. Co., Inc., Calif (o,cc)
Wilson-Hurd Mfg. Co., Inc., Wis (cc)
Wright, Albert Screw Machine Products, Calif (bb)

Aluminum Bronze

(see Copper)

Anodes

(see specific metal)

Anodic Coatings

(see Conversion Coatings)

Asbestos

American Asbestos Textile Corp., Pa (r,s)
American Brakeblok Div., American Brake Shoe Co., Mich (r)
American Smelting & Refining Co., NY (s)
Asbestos Corp. of America, NJ (r,s)
Asbestos Textile Co., Inc., Ill (r,s,cc)
California Metal Enameling Co., Calif (r)
Carey, Philip Mfg. Co., Ohio (r,s,cc)
Carolina Asbestos Co., NC (r)
Chicago Gasket Co., Ill (cc)
Connell Asbestos Mfg. Co., NY (r)
Dumont Corp., Calif (r,z,bb,cc,ee)
Firestone Tire & Rubber Co., World Bestos Div., Ind (r,cc)
Garlock Packing Co., NY (r,s,cc,ee)
Gatke Corp., Ill (r)
General Asbestos Gasket Mfg. Corp., Mo (r)
General Gasket, Inc., Conn (r)
Hall, C. P. Co., Ohio (s)
Johns-Manville Corp., NY (r,s,aa,cc,ee)
Keasbey & Mattison Co., Pa (s,cc,ee)
Mica Fabricating Co., NJ (s)
National Gasket & Washer Mfg. Co., Inc., NY (r,cc)
Nicolet Industries, Inc., NY (r,s,cc,ee)
North American Asbestos Corp., Ill (r,s)
Panelyte Div., St. Regis Paper Co., NY (bb,cc)
Peerless Products Industries, Ill (r)
Philadelphia Asbestos Corp., Pa (r)
Precision Paper Tube Co., Ill (ee)
Raybestos-Manhattan, Inc., NJ (bb,cc)
Raybestos-Manhattan, Inc., Raybestos Div., Conn (r)
Rogers Corp., Conn (cc)
Rostone Corp., Ind (r)
Ruberoid Co., NY (s)
Russell Mfg. Co., Conn (r,s)
Smith Chemical & Color Co., Inc., NY (aa)
Southern Asbestos Co., NC (r,s,ee)
Standard Asbestos Mfg. Co., Ill (r,s)
Staver Co., Inc., NY (r,cc)
Stone Paper Tube Div., Stone Straw Corp., Washington, DC (ee)
Union Asbestos & Rubber Co., Ill (r, cc,ee)
U.S. Polymeric Chemicals, Inc., Conn (s)
U.S. Rubber Co., NY (s)
U.S. Stoneware Co., Ohio (r)
Vellumoid Co., Mass (r,cc)
Victor Mfg. & Gasket Co., Ill (r,cc)

Balsa Wood

(see Wood)

Bar

(see specific metal)

Beryllium

Advance Stamping Co., Mich (dd)
American Silver Co., Inc., NY (v,dd)

Babson Dow Mfg. Co., Mass (o)
Belmont Smelting & Refining Works, Inc., NY (o,aa)
Beryllium Corp., Pa (o,q,w,aa,bb)—Ad p 155
Bridgeport Brass Co., Conn (dd)
Brinkerhoff Brass & Bronze Works, Inc., NY (dd)
Brush Beryllium Co., Ohio (o,q,v,w,z,aa,bb,cc,dd,ee)—Ad p 149
Craft Metal Spinning Co., Ill (cc)
Dudek & Bock Spring Mfg. Co., Ill (ff)
General Plate Div., Metals & Controls Corp., Mass (v)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Inshield Die & Stamping Co., Ohio (dd)
Instrument Specialties Co., Inc., NJ (bb,dd,ff)—Ad p 381
Lundquist Tool & Mfg. Co., Inc., Mass. (cc,dd)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (dd,ff)
Mallory, P.R. & Co., Inc., Ind (bb, dd,ff)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb)
Nuclear Metals, Inc., Mass (w,bb,cc, dd,ee,ff)
Olds Alloys Co., Calif (ee)
Oregon Metallurgical Corp., Ore (w)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (bb,dd,ff)
Sel-Rex Corp., NJ (n)
Seymour Mfg. Co., Conn (bb)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa. (o,q,v,w,z,bb,cc,dd,ee)

Beryllium Copper

(see Copper)

Billets

(see specific metal)

Bismuth and Its Alloys

Alpha Metals, Inc., NJ (o,q,v,bb,cc,dd)
American Metal Climax, Inc., NY (o,w,aa)
Anaconda Co., NY (o)
Belmont Smelting & Refining Works, Inc., NY (n,o,w,aa)
Cerro de Pasco Sales Corp., NY (w)—Ad p 154
Division Lead Co., Ill (o,ff)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Federated Metals Div., American Smelting & Refining Co., NY (o,w)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (aa)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ (aa)—Ad p 415
Peerless Alloy Co., Colo (o,w)
Republic Metals Co., Inc., NY (o,w)
River Smelting & Refining Co., Ohio (o)
Sel-Rex Corp., NJ (n)
U.S. Smelting, Refining & Mining Co., NY (w,dd)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)

Borides

(see Refractories)

Brass

(see Copper)

Brazing Alloys

Abalon Precision Mfg. Corp., NY
All-State Welding Alloys Co., Inc., NY
American Platinum & Silver Div., Engelhard Industries, Inc., NY —Ad p 461
American Products Corp., Ill
American Silver Co., NY
Ampco Metal, Inc., Wis
Belmont Smelting & Refining Works, Inc., NY
Bridgeport Brass Co., Conn
Burgess-Norton Mfg. Co., Ill
Crucible Steel Co. of America, Pa
Dana Corp., Auburn Div., Ind
Dormont Mfg. Co., Pa
Electric Materials Co., Pa
Eutectic Welding Alloys Corp., NY
Falstrom Co., NJ
General Findings & Supply Co., Industrial Div., Mass
Glidden Co., Ind
Glidden Co., Chemicals-Pigments-Metals Div., Md
Goldsmith Bros. Smelting & Refining Co., Ill
Handy & Harman, NY —Ad p 457
Hayden Wire Works, Inc., Mass
Inland Mfg. Co., Neb
International Nickel Co., Inc., NY
Kenmore Machine Products, Inc., NY
Kinkead Industries, Inc., Ill
Kling Metal Spinning & Stamping Co., NY
Kwikset Powdered Metal Products, Calif
Lincoln Iron Works, Vt
Lucas-Milhaupt Engineering Co., Wis
Machine Products Corp., Ohio
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass.
Mansol Ceramics Co., NJ
McDowell Mfg. Co. Pa
Revere Copper & Brass, Inc., NY
Sall, George Metals Co., Inc., Pa
United Wire & Supply Corp., RI
Uniworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa
Victor Equipment Co., Calif
Wall Colmonoy Corp., Stainless Process Div., Mich —Ad p 458
Waterman Industries, Inc., Calif
West Haven Foundry Co., Conn
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif
Whitehead Metal Products Co., Inc., NY

Bronze

(see Copper)

Buna N Rubber

(see Acrylonitrile-Butadiene Rubber)

Butadiene Styrene

(see Styrene Butadiene)

Butyl Rubber

(see Isoprene-Isobutylene Rubber)

Butyrate

(see Cellulose Acetate Butyrate)

Cadmium

Allied Research Products, Inc., Md (n)—Ad p 327
Alpha Metals, Inc., NJ (o,q,v,bb,cc,dd)
American Metal Climax, Inc., NY (n,o,w,aa,bb)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,q,w)
American Zinc Sales Co., Mo (n,o,z)
Anaconda Co., NY (o)
Anchor Metal Co., Inc., NY (w)
Auld, D.L. Co., Ohio (n)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,z,aa,cc)
Bunker Hill Co., Calif (n,o)
Cerro de Pasco Sales Corp., NY (z,bb)—Ad p 154
Division Lead Co., Ill (v,cc)
Eagle-Picher Co., Ohio (q)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Federated Metals Div., American Smelting & Refining Co., NY (n,o,w)
Goldsmith Bros. Smelting & Refining Co., Ill (o,w)
Hamilton Watch Co., Precision Metals Div., Pa (v,cc,dd)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hull, R.O. & Co., Inc., Ohio (n)
International Minerals and Metals Corp., NY (w)
Lucas-Milhaupt Engineering Co., Wis (dd,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (dd,ee,ff)
McGean Chemical Co., Ohio (n,dd)
Metals Disintegrating Co., Inc., NJ (aa)—Ad p 415
Modern Plating Corp., Ill (n)
New Jersey Metals Co., NJ (n)
New Jersey Zinc Co., NY (n)
Octagon Process, Inc., NY (n,o,q,w,z, bb,cc,dd)
Peerless Alloy Co., Colo (o,w)
Republic Metals Co., Inc., NY (n,o,w)
River Smelting & Refining Co., Ohio (w)
St. Joseph Lead Co., NY (n,o,w)
Sel-Rex Corp., NJ (n)
Stevens, Frederic B., Inc., Mich (n)
Triangle Conduit & Cable Co., Inc., NJ (ff)
Udylite Corp., Mich (n,bb,cc,ff)
U.S. Smelting, Refining & Mining Co., NY (o,w,bb)

Calorized Coatings

(see Diffusion Coatings)

Carbides

(see Cermets, Refractories and specific metal)

Carbon, Graphite

Becker Bros. Carbon Co., Ill (r,z,aa, bb,cc,ee)
Black Bear Co., Inc., NY (aa)
Blaco Mfg. Co., Ohio (aa)
Carbone Corp., NJ (r)
Dixon, Joseph Crucible Co., NJ (z, aa,bb)
Electro Chemical Engineering & Mfg. Co., Pa (r)
Gibson Electric Co., Pa (r,aa)
Graphite Metallizing Corp., NY (r)
Graphite Products Corp., Ohio (aa)
Graphite Specialties Corp., NY (r,bb,ee)—Ad p 288
Great Lakes Carbon Corp., NY (r,z,bb)
Heil Process Equipment Corp., Ohio (r)
Henrite Products Corp., Ohio (r)
Hofford Varnish Co., Inc., NJ (r)
Industrial Tectonics, Inc., Mich (r)
Markal Co., Ill (z)
Metallized Carbon Co., NY (r)
Morganite, Inc., NY (r,bb,ee)
National Carbon Co., Div. of Union Carbide Corp., NY (r,z,aa,bb,ee,)—Ad p 299
Ohio Carbon Co., Ohio (r,z,aa,bb,cc,ee)—Ad p 415
Pure Carbon Co., Inc., Pa (bb)
Russell Mfg. Co., Conn (r,s)

KEY

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x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

St. Marys Carbon Co., Pa (r,z)
Serwell Products Co., Ohio (aa)
Smith Chemical & Color Co., Inc., NY (aa)
Speer Carbon Co., Pa (r)
Stackpole Carbon Co., Pa (r,z,bb,ee)—Ad p 296
Superior Carbon Products, Inc., Ohio (r)—Ad p 416
United Carbon Products Co., Mich (r, z,aa,bb,cc,ee)
U.S. Graphite Co., Div. of Wickes Corp., Mich (r)

Carbon Steel

(see Steel)

Casting Resins

(see specific plastic or rubber)

Castings, Centrifugal

Al-Fin Div., Fairchild Engine & Airplane Corp., NY (a,e)
All Metals Precision Casting Corp., NY (a,b,g)
Allegheny Ludlum Steel Corp., Pa (g)
Alloy Precision Castings Co., Ohio (a, b,c,e,f)
American Brake Shoe Co., NY (a,b,j)
American Cast Iron Pipe Co., Ala (a,c,f,g)
American Crucible Products Co., Ohio (b)
Ampco Metal, Inc., Wis (b)
Asco Sintering Corp., Calif (a,b)
Baldwin-Lima-Hamilton Corp., Eddystone Div., Pa (a,b,f)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Blaw-Knox Co., Pa (f,g)
Buckeye Brass & Mfg. Co., Ohio (a)
Bunting Brass & Bronze Co., Ohio (b)
Calorizing Co., Pa (f,g)
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich (c,g)
Centrifugal Casting Machine Co., Okla (a,b)
Centrifugally Cast Products Div., Shenango Furnace Co., Ohio (b,c,f)
Centr-O-Cast & Engineering Co., Mich (a)
Comet Metal Products Co., Inc., NY (d)
Cooper Alloy Corp., NJ (g)
Copper & Brass Sales Inc., Mich (b)
Curtiss-Wright Corp., Metal Processing Div., NY (g)
Cyril Bath Co., Ohio (g)
Dayton Foundry, Calif (c)
Division Lead Co., Ill (d)
Duraloy Co., Pa (f,g)—Ad p 401
Electric Steel Foundry Co., Ore (f,g,h)
Electro-Alloys Div., American Brake Shoe Co., Ohio (g)
Engineered Castings Div., American Brake Shoe Co., NY (c,g)
Florence Pipe Foundry & Machine Co., NJ (c)
Frasse, Peter A. & Co., Inc., NY (g)
General Alloys Co., Mass (f)
General Electric Co., Foundry Dept., NY (a,b)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f)
Hi-Grade Alloy Corp., Ill (d,j)
Hughes Tool Co., Tex (g)
Humphrey Castings, Inc., Calif (a,b,f, g)
Illinois Precise Casting Co., Ill (a, b,f,g)
International Nickel Co., Inc., NY (f)
Janney Cylinder Co., Pa (a,b,c,f)
Johnson Bronze, Pa (b)
Kay-Brunner Steel Products, Inc., Calif (g)
Lebanon Steel Foundry, Pa (g)
Linton Precision Casting Co., Ind (a, b,c,f,g,j)
Magnolia Metal Co., NJ (b)
Mallory, P.R. & Co., Inc., Ind (b)
McCarter Iron Works, Inc., Pa (c,g)
Meehanite Metal Corp., NY (c)—Ad pp 378, 379
Metal Goods Corp., Mo (a,b,c,f)
Metals Processing Div., Curtiss-Wright Corp., NY (f,g)
Milwaukee Aluminum & Brass Foundry, Wis (a,b)
Misco Precision Casting Co., Mich (c, f,g)
Moccasin Bushing Co., Tenn (a)
National Bearing Div., American Brake Shoe Co., Pa (b)
National Lead Co., NY (b,d)
National Lead Construction Co., Inc., NJ (l)
Ohio Steel Foundry Co., Ohio (f)
Olds Alloy Co., Calif (a,b,d,f)
Oregon Metallurgical Corp., Ore (h)
Precision Founders, Inc., Calif (a,b,c,f, g,j)
Precision Metalsmiths, Inc., Ohio (a, b,c,d,f,g)
Quality Electric Steel Castings, Inc., Tex (g)
Saginaw Bay Industries, Inc., Mich (a,e)
Sandusky Foundry & Machine Co., Ohio (b,f,g)—Ad p 47
Schilling Bronze Co., NY (b,d,f,j)
Sheller Mfg. Corp., Mich (j)
Sorbo-Mat Process Engineers, Mo (c)
Stainless Foundry & Engineering, Inc., Wis (f,g)
State Foundry & Machine Co., Wis (c)
Staver Co., Inc., NY (d)
Stoody Co., Calif (d)
Swayne-Robinson & Co., Ind (a,c)
Terre Haute Bronze & Brass Foundry, Ind (b)
Thys Co., Calif (a,b,c,f,g)
True Alloys, Inc., Mich (a,b,d,f,j)
U.S. Pipe & Foundry Co., Ala (c,g)
Uniworld Research Corp. of America, Ohio (c)
Utica Drop Forge & Tool Co., NY (f, g)
Vollrath Co., Wis (g)
Weatherhead Co., Ind (j)
West Steel Casting Co., Ohio (f)
Whitehead Metal Products Co., Inc., NY (f)
Winters Foundry & Machine Co., Inc., Ohio (a,b)
Wisconsin Centrifugal Foundry, Inc., Wis (a,b,d,f,g)

Castings, Die

A & A Die Casting Co., Calif (a,d,j)
Able Tool & Engineering Co., Ill (a,j)
Accurate Die Casting Co., Ohio (a,e,j)
Accurate Metal Weather Strip Co., Inc., NY (j)
Admiral Die Castings Div., Portable Electric Tools, Inc., Ill (a,j)
Advance Pressure Castings, Inc., NY (a,j)
Advance Tool & Die Casting Co., Wis (a,j)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (a,j)
Allen-Stevens Corp., NY (j)
Aluminum Co. of America, Pa (a)
Ambrit Industries, Inc., Calif (a,d,j)
American Aluminum Castings Co., NJ (a)
American Crucible Products Co., Ohio (b)
American Foundries Co., Mich (c)
American Foundry & Machine Div., Elmco Corp., Utah (g)
Auel Industries, Pa (j)
Auld, D.L. Co., Ohio (a,j)
Aurora Metal Co., Ill (b)
Badger Die Casting Corp., Wis (a,j)
Belmont Smelting & Refining Works, Inc., NY (a,d)
Beloit Foundry Co., Ill (c)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Briel Industries, Inc., Ind (a)
Centrifugal Casting Machine Co., Okla (a)
Centr-O-Cast & Engineering Co., Mich (a)
Century Die Casting Co., Ill (a,j)
Char-Lynn Co., Diecasting Div., Minn (a,j)
Chicago White Metal Casting, Inc., Ill (a,j)
Cincinnati Foundry Co., Ohio (c)
Comet Metal Products Co., Inc., NY (j)
Conneaut Die Casting Co., Ohio (a,j)
Continental Die Casting Corp., Mich (j)
Crown Metal Co., Wis (d)
Crucible Steel Co. of America, Pa (c,f,g)
Davis Products Corp., NY (j)
Dayton Bronze Bearing Co., Ohio (a,j)
Dayton Malleable Iron Co., Ohio (a)
Die Cast Products, Inc., Calif (a,j)
Diecast Corp., Mich (a,j)
Division Lead Co., Ill (d)
Doehler-Jarvis Div., National Lead Co., Ohio, (a,b,e,j)
Dollin Corp., NJ (a,d,j)—Ad p 416
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Duane Specialties, Ltd., NJ (j)
Du-Wel Metal Products, Inc., Mich (a,j)
Electric Auto-Lite Co., Ohio (a,j)
Federal Die Casting Co., Ill (a)
General Electric Co., Foundry Dept., NY (b)
General Motors Corp., Fabricast Div., Ind (a)
Grammes, L.F. & Sons, Inc., Pa (j)
Grand Rapids Brass Co., Mich (j)
Grey, C.M. Industries, Inc., NJ (a,j)
Gries Reproducer Corp., NY (j)—Ad p 424
Hamilton Die Cast, Inc., Ohio (a,j)
Hampden Brass & Aluminum Co., Mass (a,j)
Harbot Die Casting Corp., NJ (a)
Hardy Mfg. Corp., Ind (a,j)
Harvey Aluminum Sales, Inc., Calif (a,j)
Harvill Corp., Calif (a,b,e,j)
Hercules Fastener Co., Ill (j)
Hilfinger Corp., Ohio (j)
Hoover Co., Die Casting Div., Ohio (a, j)
Humphrey Castings, Inc., Calif (a)
Jersey Plastic & Die Casting Co., NJ (a,j)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kamin Die Casting & Mfg. Co., Ill (a,j)
Kent Castings Corp., Mich (j)
Kiowa Corp., Iowa (a,j)
Krone, Paul Die Casting Co., Ill (a,j)
La France Precision Casting Co., Pa (j)
Lake Erie Foundry Co., NY (c)
Latrobe Die Casting Co., Pa (a,d,j)
Lester Castings, Inc., Ohio (a,j)
Light Metals, Inc., Ind (a,e)
Litemetal Dicast, Inc., Mich (e)
Littlestown Hardware & Foundry Co., Inc., Pa (a)
Livingston-Tyler Products, Ohio (j)
Madison Kipp Corp., Wis (a,j)
Magline Inc., Mich (a,e)
Mallory, P.R. & Co., Inc., Ind (b,h)
Manor Die Cast Corp., Ohio (a)
Meehanite Metal Corp., NY (c)—Ad pp 378, 379
Meta-Mold Aluminum Co., Sub. of Dayton Malleable Iron Co., Wis (a,e)
Milwaukee Die Casting Co., Wis (a,d,j)
Missouri Diecasting Co., Mo (a,j)
Model Brass Co., Inc., Ill (a,b)
Moldcast Products, Inc., NJ (a)
Monarch Aluminum Mfg. Co., Ohio (a,j)
Monarch Tool & Mfg. Co., Ky (j)
Mt. Vernon Die Casting Corp., Conn (a)
National Die Casting Co., Ill (a,j)
National Lead Co., NY (a,b,d,e,j)
National Lead Construction Co., Inc., NJ (d)
National Malleable & Steel Castings Co., Ohio (j)
National Supply Co., Industrial Products Div., Calif (g)
New England Die Casting Co., Conn (a,j)
New Jersey Zinc Co., NY (j)—Ad pp 386-387
New Products Corp., Mich (a,e)
Newton-New Haven Co., Conn (a,j)
Norgren-Stemac, Inc., Colo (j)
Olderman Mfg. Corp., Conn (j)
Paragon Die Casting Co., Ill (a,j)
Paramount Die Casting Co., Mich (a, e,j)
Parker White Metal Co., Pa (a,d,f,j)
Peasley Products, Inc., Conn (a,j)
Phoenix Die Casting Co., NY (a,j)
Pittsburgh Die & Casting Co., Pa (a,j)
Pressure Castings, Inc., Ohio (a,j)
Production Die Casting Co., Tex (a,e,j)
Rangers Die Casting Co., Calif (a,j)
Republic Die Casting Co., Mo (a,j)
Republic Metals Co., Inc., NY (d)
Rupert Diecasting Co., Mo (a,j)
St. Louis Diecasting Corp., Mo (a,j)
St. Marys Foundry Co., Ohio (c)
Sargent & Greenleaf, Inc., NY (a,j)
Schilling Bronze Co., NY (a,b,d,f,j)
Schneider, Bowman Co., Inc., Pa (c)
Schultz Die Casting Co., Ohio (a,j)
Sillcocks Miller Co., NJ (a,c,d,j)
Southern Metal Products Co., La (a)
Star Heel Plate Co., Inc., NJ (a,j)
Staver Co., Inc., NY (d)
Stella Products Corp., NJ (j)
Sterling Die Casting Co., NY (a,j)
Stewart-Warner Corp., Stewart Die Casting Div., Ill (a,e,j)
Stoody Co., Calif (a,b,d,e)
Stuart Foundry Co., Mich (c)
Superior Die Casting Co., Ohio (a,j)
Thompson Products, Light Metals Div., Ohio (a)
Titan Metal Mfg. Co., Pa (b)—Ad p 388
Tower Grove Foundry, Mo (c)
Twin City Die Casting Co., Minn (a, d,j)
Veeder-Root, Inc., Conn (j)
Vulcan Rail & Construction Co., NY (a,c,g)
Weber-Knapp Co., NY (a)
West Irving Die Casting Co., Ill (a)
Westland Die Casting, Inc., Calif (a,j)
Wheaton Die Casting Corp., NJ (a,j)

Castings, Investment

All Metals Precision Casting Corp., NY (a,b,g)
Alloy Precision Castings Co., Ohio (a, b,c,e,f,g)
Arwood Precision Castings Corp., NY (a,b,e,g)

Atlantic Casting Engineering Corp., NJ
—Ad p 398
Austenal Co., Div. of Howe Sound Co., NY (a,c,f,g)
Bone Engineering Corp., Calif (a,b,f,g)
Buckeye Brass & Mfg. Co., Ohio (a, b,c,g)
Budd-Stanley Co., Inc., NY (a,b,e,f,h,j)
Casting Engineers, Inc., Ill (a,b,c,f,g)
Centrifugal Casting Co., NY (a,b,e,f, h,j)
Chrysler Corp., Mich (a,b,c,e,f,g,h,j)
Eaton Mfg. Co., Foundry Div., Mich (c)
Electric Steel Foundry Co., Ore (h)
Electronicast Div., Nilsen Mfg. Co., Ill (a,b,c,e,f,g,h,j)
Engineered Precision Casting Co., NJ (a,b,c,f,g)
General Motors Corp., Fabricast Div., Ind (a,f)
Gray-Syracuse, Inc., NY (a,b,c,f,g)
Harcast Co., Inc., Pa (a,b,c,f,g)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (c,f,g)
Hawkridge Bros. Co., Mass (a,b,c,e,f, g,h,j)
Hitchiner Mfg. Co., Inc., NH (a,b,c, f,g)
Howard Foundry Co., Ill (a,b,c,f,g)
Humphrey Castings, Inc., Calif (a,b,f,g)
Illinois Precise Casting Co., Ill (a,b, f,g)
International Nickel Co., Inc., NY (f)
Investment Casting Co., NJ (a,b,c,f,g)
Jelrus Precision Casting Corp., NY (a,b,c,e,f,g,b,j)
Joseff-Hollywood Co., Calif (a,b,c,g)
Kolcast Industries Div., Thompson Products, Inc., Ohio (a,c,f,g)
Lawrence Laboratory, Calif (a,b,e)
Lebanon Steel Foundry, Pa
(g)
Linton Precision Casting Co., Ind (a,b,c,f,g,j)
Loeffler, J.M. Co., Machine & Brass Works, Pa (b)
Lynn Casting Corp., Calif (a,b,d,f,g)
Manco Products, Inc., Mich (f,g)
Meehanite Metal Corp., NY
(c)—Ad pp 378, 379
Mercast Mfg. Corp., Calif (a,b,c,e,f,g)
Metal Goods Corp., Tex (f)
Midwest Precision Castings Co., Ohio (a,b,c,f,g)
Misco Precision Casting Co., Mich (c,f,g)
National Precision Casting Corp., Div. of Beryllium Corp., Pa (a,b,c,f,g)
Omni-Metal Castings, Inc., NY (a, b,c,f,g)
Picco, Inc., Calif (a,b,c,f,g)
Precision Castparts Corp., Ore (a,b, f,g)
Precision Founders, Inc., Calif (a, b,c,f,g,j)
Precision Metalsmiths, Inc., Ohio (a, b,c,d,f,g)
Rausch Mfg. Co., Inc., Minn (a,b)
Rode, Inc., Mass (a,b)
Rolle Mfg. Co., Pa (a,b,e,g)
Solon Foundry, Inc., Ohio (a,e)
Star Heel Plate Co., Inc., NJ (a,b)
Staver Co., Inc., NY (d)
Thompson, K.W. Tool Co., NY (a,b, c,e,f,g,h,j)
Thys Co., Calif (a,b,c,f,g)
United Shoe Machinery Corp., Mass (g)
Uniworld Research Corp. of America, Ohio (c,f)
Vascoloy-Ramet Corp., Ill (b,g)
Wall Colmonoy Corp., Stainless Process Div., Mich
(c,f)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
(a,b,c,f,g,h)
Whitehead Metal Products Co., Inc. NY (f)
York Casting, Inc., NY (a,b,c,e,f,g, h,j)
Z & H Mfg. Co., NY (a,b,c,e,f,g,h,j)

Castings, Nonmetallic

(plastics and rubber)

A & A Die Casting Co., Calif (k)
Ace Plastic Co., NY (l)
Acushnet Process Co., Mass
(m)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (k,l)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (1)
Auburn Plastic Engineering, Ill (k)
Automotive Rubber Co., Inc., Mich (m)
Biggs, Carl H. Co., Inc., Calif (k,l)
Boonton, Molding Co., NJ (k,l,m)
Buckeye Molding Co., Ohio (k)
Cadillac Plastic & Chemical Co., Mich (k)
Campro Co., Ohio (k)
Cast Optics Corp., NJ (k,l)
Cellcote Co., Ohio (l)
Chemical Coatings & Engineering Co., Pa (k,l,m)
Chemical Coatings & Engineering Co., Pa (k,l,m)
Chemical Development Corp., Mass (l)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (k)
Disogrin Industries, Inc., NY (m)
Douglas & Sturgess, Calif (l,m)
Duriron Co., Inc., Ohio (l)
Eby, Hugh H. Co., Pa (k,l)
Eclipse Plastic Industries, Inc., Fla (k)
Electric Auto-Lite Co., Ohio (k,l)
Eljay Corp., Md (l)
Emerson & Cuming, Inc., Mass (k,l,m)
Foss Mfg. Co., Plastics Div., Id (l)
Fry Plastics Co., Calif (k,l)
General Mills, Inc., Chemical Div., Ill (k,l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Grimes Mfg. Co., Plastic Research Products, Ohio (l)
Hays Mfg. Co., Pa (l)
Houghton Laboratories, Inc., NY
(l)
Kerr, R.W. Plastic Co., Neb (k,l,m)
Kurz Kasch, Inc., Ohio (l)
Marblette Corp., NY (l)
Mechanical Rubber Products Co., NY (l)
Minnesota Rubber Co., Minn (l,m)
Minnesota Rubber & Gasket Co., Minn (k,m)
Munray Products Div., Fanner Mfg. Co., Ohio (k,m)
New England Tape Co., Inc., Mass (l)
Polycast Corp., Conn (k,l)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa
(k)
Pyrosil, Inc., Ohio (l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Ren Plastics, Inc., Mich (l)
Robot Devices, Inc., Va (l)
Sewell Mfg. Co., Mich (l)
Sierra Electric Corp., Calif (k)
Superior Plastics, Inc., Ill (k)
Sylvania Electric Products, Inc., Parts Div., Pa
(k,l)
Trostel, Albert Packing, Ltd., Wis (l)
U.S. Stoneware Co., Ohio (k)

Castings, Permanent Mold

A C F Industries, Inc., NY (e)
Abco Aluminum & Brass Works, Tex (a,d)
Acme Aluminum Foundry Co., Ill (a)
Advance Aluminum Castings Corp., Ill (a)
Al-Fin Div., Fairchild Engine & Airplane Corp., NY (a,e)
Aluminum Alloys Corp., Mich (a)
Aluminum Co. of America, Pa (a)
Aluminum Casting & Engineering Co., Wis (a,j)
Aluminum Industries, Inc., Ohio (a)
Aluminum Permanent Mold Co., Mich (a)
American Aluminum Castings Co., NJ (a)
American Brake Shoe Co., NY (a,b,j)
American Metal Climax, Inc., NY (b)
Apex Steel Corp., Ltd., Calif (g)
Baldt Anchor, Chain & Forge Div., Boston Metals Co., Pa (a,b)
Baldwin-Lima-Hamilton Corp., Eddystone Div., Pa (a,b,f)
Belmont Smelting & Refining Works, Inc., NY
(a,d,j)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Bohn Aluminum & Brass Corp., Mich (a)
Briggs-Shaffner Co., NC (a)
Bronze & Steel Die Casting Co., Ill (b)
Buckeye Brass & Mfg. Co., Ohio (a, b,j)
Bunker Hill Co., Calif (d,j)
Bunting Brass & Bronze Co., Ohio
(b)
Calumet Div., Calumet & Hecla, Inc., Mich (c)
Centrifugal Casting Machine Co., Okla (a)
Centr-O-Cast & Engineering Co., Mich (a)
Chattanooga Aluminum Foundry, Inc., Tenn (a)
Cochrane Foundry, Inc., Pa (a,b,j)
Crown Metal Co., Wis (d)
Davis Products Corp., NY (j)
Dayton Malleable Iron Co., Ohio (a)
Derby Castings Co., Conn (a)
Dirilyte Co. of America, Inc., Ind (b)
Division Lead Co., Ill (d)
Dixie Bronze Co., Ala (a,b,f)
Dostal Foundry & Machine Co., Mich (c)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Eaton Mfg. Co., Foundry Div., Mich (c)
Electric Steel Foundry Co., Ore (f,g)
Enterprise Wheel & Car Corp., Va (a)
Est Co., Inc., Wis (a,e)
Exalco Mfg. Co., Ohio
(a)—Ad p 414
Fairfield Aluminum Casting Co., Iowa (a)
Flynn, Michael Mfg. Co., Pa (a)
Foster Aluminum Alloy Products Corp., NY (a)
General Aluminum Mfg. Co., Ohio (a,e)
General Electric Co., Foundry Dept., NY (c)
General Motors Corp., Fabricast Div., Ind (a)
Gilbert Brass & Foundry Co., Mo (a)
Gillett & Eaton, Inc., Minn (a,c)
Hampden Brass & Aluminum Co., Mass (a)
Harvill Corp., Calif (a,e)
Howard Foundry Co., Ill (a,e)
Humphrey Castings, Inc., Calif (a)
Johnson Bronze Co., Pa (b)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Lebanon Steel Foundry, Pa
(g)
Light Metals, Inc., Ind (a,e)
Light Metals Dept., American Brake Shoe Co., NJ (a,e)
Littlestown Hardware & Foundry Co., Inc., Pa (a)
Magline, Inc., Mich (a,e)
Magnolia Metal Co., NJ (b)
Mallory, P.R. & Co., Inc., Ind (h)
Manco Products, Inc., Mich (b)
Manor Die Cast Corp., Ohio (a)
Mansfield Brass & Aluminum Corp., Ohio (a)
Marshall Car & Wheel Foundry Co., Inc., Tex (c)
McLanahan & Stone Corp., Pa (c)
Meehanite Metal Corp., NY
(c)—Ad pp 378, 379
Metal Mold Magnesium Corp., Wis (e)
Meta-Mold Aluminum Co., Sub of Dayton Malleable Iron Co., Wis (a,e)
Moccasin Bushing Co., Tenn (a)
Moldcast Products, Inc., NJ (a)
Monarch Aluminum Mfg. Co., Ohio (a)
Morse, Fred W. Co., RI (a,j)
National Aluminum Mfg. Co., Ill (a)
National Lead Construction Co., Inc., NJ (d)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Nuclear Metals, Inc., Mass (a,b,c,e,f,g,h)
Olds Alloys Co., Calif (b,d,f)
Oregon Metallurgical Corp., Ore (h)
Parker, Charles Co., Conn (a,j)
Peasley Products, Inc., Conn (a,j)
Permold Co., Ohio (a)
Rolle Mfg. Co., Pa (a,e)
Saginaw Bay Industries, Inc., Mich (a,e)
Sandusky Foundry & Machine Co., Ohio
(b)
Schilling Bronze Co., NY (a,b,d,f,j)
Schmeller Aluminum Foundry Co., Ohio (a)
Skookum Co., Inc., Ore (g)
Sorbo-Mat Process Engineers, Mo (c)
Standard Magnesium Corp., Okla (e)
Star Heel Plate Co., Inc., NJ (a,b)
Staver Co., Inc., NY (d)
Sterling Aluminum Products, Inc., Mo (a)
Stewart-Warner Corp., Stewart Die Casting Div., Ill (a)
Superb Light Alloys, Inc., NY (a,e)
Texas Foundries, Inc., Tex (c,g)
Thompson Products, Light Metals Div., Ohio (a)
True Alloys, Inc., Mich (a,b,d,j)
Universal Castings Corp., Ill (a,b)
Vulcan Rail & Construction Co., NY (a,c)
Waterman Industries, Inc., Calif (a)
Wellman Bronze & Aluminum Co., Ohio (a,e)
Williams, A.C. Co., Ohio (e)
Winters Foundry & Machine Co., Inc., Ohio (a)
Wisconsin Aluminum Foundry Co., Inc., Wis (a,b)

Castings, Plaster Mold

Al-Fin Div., Fairchild Engine & Airplane Corp., NY (a,e)
All Metals Precision Casting Corp., NY (a,b)
Alloy Precision Castings Co., Ohio (a,b,c,e,f,g)
Aluminum Co. of America, Pa (a)
Atlantic Casting Engineering Corp., NJ
(a,b)
Bean, Morris & Co., Ohio (a)
Beloit Foundry Co., Ill (c)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a)
Chattanooga Aluminum Foundry, Inc., Tenn (a)
Curtiss-Wright Corp., NY (g)
Derby Castings Co., Conn (a)
General Motors Corp., Fabricast Div., Ind (a)
Hampden Brass & Aluminum Co., Mass (a)
Humphrey Castings, Inc., Calif (a)
Lebanon Steel Foundry, Pa
(g)
Light Metals Dept., American Brake Shoe Co., NJ (a)
Lincoln Foundry Corp., Calif (c)
Loeffler, J.M. Co., Machine & Brass Works, Pa (b)
Meehanite Metal Corp., NY
(c)—Ad pp 378, 379
Mercast Mfg. Corp., Calif (a,b,c,e,f,g)
Ohio Precision Castings, Inc., Ohio (a,b,f)
Olderman Mfg. Corp., Conn (b)
Ross-Meehan Foundries, Tenn (c,g)
Schilling Bronze Co., NY (a,b,d,f,j)
Schneider, Bowman Co., Inc., Pa (c)
Solon Foundry, Inc., Ohio (a,e)
Sorbo-Mat Process Engineers, Mo (c)
True Alloys, Inc., Mich (a,b)
Universal Castings Corp., Ill (a,b)
Wayne Foundry & Stamping Co., Mich (j)
Western Iron & Foundry Co., Inc., Kan (c)

Castings, Sand

Abco Aluminum & Brass Works, Tex (a,b,d,f,j)
Acco Malleable Casting Div., American Chain & Cable Co., Inc., Pa (c)
Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa (b,c,g)
Acme Aluminum Foundry Co., Ill (a)
Acme Foundry & Machine Co., Kan (c)
Acme Foundry & Machine Co., Okla (c)
Advance Foundry Co., Ohio (c)
Aelco Foundries, Inc., Wis (a,b,d,e,f,g)
Albany Car Wheel Co., Inc., NY (c)
Albert Lea Foundry Co., Minn (c)
Albion Malleable Iron Co., Mich (c)
Alcasco Foundry, Ill (a,b)
Al-Fin Div., Fairchild Engine & Airplane Corp., NY (a,e)
Allegheny Foundry Co., Pa (c)
Allegheny Ludlum Steel Corp., Pa
(g)
Allied Steel Castings Co., Ill (g)
Alloy Cast Steel Co., Ohio (g)
Alloy Steel Casting Co., Pa (f,g)
Almont Mfg. Co., Mich (c)
Alten Foundry & Machine Works, Inc., Ohio (c)
Aluminum Alloys Corp., Mich (a)
Aluminum Co. of America, Pa (a,e)
Aluminum Industries, Inc., Ohio (a)
Aluminum Permanent Mold Co., Mich (a)
Amalgamated Steel Corp., Ohio (g)
American Aluminum Casting Co., NJ (a)
American Brake Shoe Co., NY (a,b,j)
American Car & Foundry Div., ACF Industries, Inc., NY (c)
American Cast Iron Pipe Co., Ala
(c,f,g)
American Crucible Products Co., Ohio (b)
American Foundries Co., Mich (c)
American Laundry Machinery Co., NY (c)
American Light Alloys, Inc., NJ (a,e)
American Manganese Steel Div., American Brake Shoe Co., Ill
(g)
American Metal Climax, Inc., NY (b)
American Sanitary Mfg. Co., Ill (b)
American Steel Foundries, Ind (g)
American Steel Foundries, Ill (g)
American Steel Foundries, American Steel Castings Div., NJ (g)
Ampco Metal, Inc., Wis (b)
Apex Foundry, Inc., Mich (c,e,f)
Apex Steel Corp., Ltd., Calif (g)
Arkansas Foundry Co., Ark (c)
Arneson Foundry Co., Wis (c,g)
Arnold Engineering Co., Ill (a,c,f)
Arzt, T.L. Foundry Co., Ill (c)
Atlantic Foundry Co., Ohio (c,g)
Atlantic Steel Castings Co., Pa (g)
Atlas Brass Foundry, Calif (b)
Atlas Foundry Co., Ohio (c)
Atlas Foundry & Machine Co., Wash (c,g)
Atlas Foundry & Mfg. Co., Calif (c)
Auto Specialties Mfg. Co., Mich (c)
Badger Malleable & Mfg. Co., Wis
Copper & Brass Sales, Inc., Mich (c)
Banner Iron Works, Mo (c)
Barnard Foundry Co., Inc., Mass (b)
Barnett Foundry & Machine Co., NJ (c)
Baxter Foundry & Machine Works, Inc., Id (a,b,c)
Bay City Electric Steel Casting Co., Mich (g)
Bay City Foundry Co., Mich (c)
Bay State Tool & Machine Co., Mass (g)
Bean, Morris & Co., Ohio (c)
Bearium Metals Corp., NY (b)
Beaver Valley Alloy Foundry Co., Pa (c,g)
Bellaire Stove Co., Ohio (c)
Belle City Malleable Iron Co., Wis (c)
Beloit Foundry Co., Ill (c)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Beryllium Corp., Pa
(b)
Bethlehem Steel Co., Pa (c,g)
Bierman-Everett Foundry Co., NJ (a,b,c)
Bignall Co., NY (c)
Black-Clawson Co., Ohio (c)
Blaw-Knox Co., Pa (f,g)
Bond, Charles Co., Pa (c)
Bonnot Co., Ohio (c)
Briggs-Shaffner Co., NC (a,c)
Brinkerhoff Brass & Bronze Works, Inc., NY (a)
Bruce Foundry and Mfg. Co., Mich (c)
Buckeye Iron & Brass Works, Ohio (a,b)
Bunting Brass & Bronze Co., Ohio
(b)
Butler Engine & Foundry Co., Inc., Pa (a,b,c)
Cadillac Malleable Iron Co., Mich (c)
Calorizing Co., Pa (f,g)
Calumet Div., Calumet & Hecla, Inc., Mich (c)
Calumet Steel Castings Corp., Ind (g)
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich (c,g)
Canton Malleable Iron Co., Ohio (c)
Carondelet Foundry Co., Mo (c,f)
Case, J.I. Co., Wis (c)
Castalloy Co., Inc., Mass (a,e)
Casting Service Corp. of Michigan, Mich (c)
Central Casting Div., King-Seeley Corp., Mich (c)
Chain Belt Co., Wis (c)
Chambersburg Engineering Co., Pa (c)
Chattanooga Aluminum Foundry, Inc., Tenn (a)
Chicago Aluminum Castings, Ill (a)
Chicago Hardware Foundry Co., Ill (a,b,c)
Chicago Malleable Castings Co., Ill (c)
Cincinnati Foundry Co., Ohio (c)
Clark Bros. Co. Div., Dresser Operations, Inc., NY (c)
Clarksville Foundry & Machine Works, Tenn (c)
Cleveland Foundry & Mfg. Co., Inc., Tenn (c)
Clinton Metal Products Co., Ohio (a)
Cochrane Foundry, Inc., Pa (a,b,j)
Columbian Bronze Corp., NY (a,b,d)
Columbiana Pump Co., Ohio (c)
Commercial Iron Works, Calif (c)
Commercial Steel Casting Co., Ohio (g)
Compton Foundry, Calif (c)
Continental Gin Co., Ala (c)
Cooper Alloy Corp., NJ (g,h)
Cooper-Bessemer Corp., Ohio (c)
(a,b)
Crawford & Doherty Foundry Co., Ore (c)
Crown Non-Ferrous Foundry, Inc., Pa (a,b,f)
Crucible Steel Casting Co., Pa (g)
Curtiss-Wright Corp., Metals Processing Div., NY (f,g)
Dalton Foundries, Inc., Ind (c)
Darling Valve & Mfg. Co., Pa (c)
Dayton Bronze Bearing Co., Ohio (a,b)
Dayton Foundry, Calif (c)
Dayton Malleable Iron Co., Ohio (a,c)
Decatur Casting Co., Ind (c)
Decrow Engineering Corp., NY (a,b)
De Laval Steam Turbine Co., NJ (c)
Derby Castings Co., Conn (a,b)
De Sanno Foundry & Machine Co., Calif (a,b)
Detroit Brass & Malleable Co., Mich (c)
Deuscher, H.P. Co., Ohio (c)
Dexter Foundry Div., Philco Corp., Iowa (c)
Dirilyte Co. of America, Inc., Ind (b)
Division Lead Co., Ill (d)
Dixie Bronze Co., Ala (a,b,f)
Dodge Steel Co., Pa (g)
Dormont Mfg. Co., Pa (b)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Driver-Harris Co., NJ
(f)
Duluth Brass Works Co., Minn (a,b)
Duraloy Co., Pa
(g)—Ad p 401
Duriron Co., Inc., Ohio (c,g)
East Birmingham Bronze Foundry Co., Ala (a,b)
Eastern Malleable Iron Co., Del (g)
Ehrsam, J.B. & Sons Mfg. Co., Kan (c)
Eichinger, Charles F., La (a,b)
Electric Auto-Lite Co., Ohio (c)
Electric Materials Co., Pa (b)
Electric Steel Foundry Co., Ore (f,g)
Electro-Alloys Div., American Brake Shoe Co., Ohio (g)
Electron Corp., Colo (c,f)
Elk Engineering Works, Inc., Pa (a,b,c)
Elkhart Foundry & Machine Co., Inc., Ind (c)
Elkhart Iron Works, Mich (c)
Elyria Foundry Div., Chromalloy Corp., Ohio (c)
Emmaus Foundry & Machine Co., Pa (a,b,c)
Empire Foundry Co., Inc., Calif (c,g)
Empire Steel Castings, Inc., Pa (g)
Engineered Castings Div., American Brake Shoe Co., NY (c)
Enterprise Wheel & Car Corp., Va (a,b,c)
Erie Bronze Co., Pa (a,b)
Erie Casting Co., Pa (c)
Erie Malleable Iron Co., Pa (c)
Eureka Electric Products Co., Pa (a,b)
Fahralloy Co., Ill (g)
Fairbanks, Morse & Co., Wis (c)
Fairfield Aluminum Castings Co., Iowa (a)
Falk Corp., Wis (g)
Federal Malleable Co., Wis (c)
Fischer Casting Co., Inc., NJ (a)
Fitchburg Foundry, Inc., Mass (c)
Flood City Brass & Electric Co., Pa (a,b)
Florence Pipe Foundry & Machine Co., NJ (c)
Florin Foundry & Mfg. Co., Pa (c)
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa (f,g)
Fort Worth Steel & Machinery Co., Tex (c)
Foster Aluminum Alloy Products Corp., NY (a)
Frederick Iron & Steel, Inc., Md (c)
Fremont Casting Co., Mass (c)
Frontier Bronze Corp., NY (a,b,f)
Fulton Foundry & Machines Co., Inc., Ohio (c)
G & C Foundry Co., Ohio (c)
Gale Mfg. Co., Mich (c)
Gardner-Denver Co., Ill (c)
Gartland Foundry Co., Ind (c)
General Alloys Co., Mass (f)
General Electric Co., Foundry Dept., NY (a,b,c,f,g)
General Foundry & Mfg. Co., Mich (c)
General Malleable Corp., Wis (c)
General Metals Corp., Calif (c)
General Motors Corp., Central Foundry Div., Mich (c)

Suppliers of Materials

General Motors Corp., Fabricast Div., Ind (a)
General Steel Castings Corp., Ill (g)
Georgia Iron Works, Ga (c)
Gibson & Kirk Co., Md (a,b,f)
Gilbert Brass Foundry Co., Mo (a,b)
Gillett & Eaton, Inc., Minn (a,c)
Glover Machine Works, Ga (g)
Gluntz Brass & Aluminum Foundry Co., Ohio (a,b,j)
Goslin Birmingham Mfg. Co., Inc., Ala (c,g)
Gowanda Furnaces, Inc., NY (c)
Grafton Foundry Co., Wis (c)
Graham, James Co., Conn (b)
Gra-Iron Foundry Corp., Iowa (c)
Green Bay Foundry & Machine Works, Wis (a,b,c)
Greenlee Foundry Co., Ill (c)
Grimm Foundry Co., Inc., NJ (c)
Gunite Foundries Corp., Ill (c,g)
H & H Foundry Machine Co., Pa (c)
Hallstead Foundry, Inc., Pa (c)
Hamilton Foundry & Machine Co., Ohio (c)
Hampden Brass & Aluminum Co., Mass (a,b,j)
Hansell-Elcock, Ill (c)
Hardinge Mfg. Co., Pa (c)
Hartford Electrical Steel Corp., Conn (g)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f)
Hays Mfg. Co., Pa (b)
Headford Bros. & Hitchins Foundry Co., Iowa (c)
Helmick Foundry-Machine Co., WVa (c)
Hewitt, John Foundry Co., NJ (a,b,c)
Hica, Inc., La (f,g)
Hills-McCanna Co., Ill (d)
Hobbs, Clinton E. Co., Mass (a,b,c)
Hodgson Foundry Co., Ill (a,b,c,d)
Hoffman Bronze & Aluminum Casting Co., Ohio (a,b)
Homestead Valve Mfg. Co., Pa (a,b,c,f)
Howard Foundry Co., Ill (a,b,c,e,f,g)
Humphrey Castings, Inc., Calif (a)
Hunt-Spiller Mfg. Corp., Mass (c,g)
I-F Mfg. Co., Ohio (c)
Illinois Iron & Bolt Co., Ill (a,f)
Independence Stove & Mfg. Co., Mo (c)
Indiana Brass Co., Inc., Ind (b)
Industrial-Ferguson Foundry Corp., NJ (a,b,f,j)
International Nickel Co., Inc., NY (f)
Iowa Malleable Iron Co., Iowa (c)
Ironton Malleable Div., Dayton Malleable Iron Co., Ohio (c)
Irwin-Sensenich Corp., Pa (c)
Jamestown Malleable Iron Corp., NY (c)
Jessop Steel Co., Pa (c,g)
Johnson Bronze Co., Pa (b)
Johnstone Foundries, Inc., Pa (c)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kanawha Mfg. Co., W. Va (c)
Kansas City Hay Press Co., Mo (c)
Kay-Brunner Steel Products, Inc., Calif (g)
Keen Foundry Co., Inc., Ind (c)
Kelly Foundry Co., Pa (c)
Kingsport Foundry & Mfg. Corp., Tenn (a,b,c,f)
Klinzing, A.F. Co., Inc., Wis (c,g)
Koehring Co., Wis (c)
Kramer Bros. Foundry Co., Ohio (c)
Kutztown Foundry & Machine Corp., Pa (c)
L F M Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan (g)
Laconia Malleable Iron Co., NH (c)
Lake Erie Foundry Co., NY (c)
Lakeside Bronze, Inc., NY (a,b)
Lakeside Malleable Casting Co., Wis (c)
Langsenkamp-Wheeler Brass Works, Inc., Ind (a,b)
La Porte Foundry Co., Ind (c)
Larson, W.O. Foundry Co., Ohio (c)
Lattimer Foundry and Machine Co., Pa (a)
Lawrence Copper & Bronze Co., Pa (b)
Lawton, C.A. Co., Wis (a,c)
Lebanon Steel Foundry, Pa (g)—Ad p 402
Le Baron, E.L. Foundry, Mass (c)
Lee Bros. Foundry Co., Inc., Ala (b)
Lehigh Foundries Co., Div. of Lehigh, Inc., Pa (c)
Leitelt Bros., Inc., Ill (a,b)
Letukas Foundry, Ind (c)
Lewistown Foundry & Machine Co., Pa (a,c,d)
Liberty Foundry Co., Mo (c,g)
Light Metals, Inc., Ind (a,e)
Light Metals Dept., American Brake Shoe Co., NJ (a)
Lincoln Foundry Corp., Calif (c)
Lincoln Iron Works, Vt (a,c,g)
Link-Belt Co., Ill (c)
Littite Foundries, Inc., Mich (c)
Littlestown Hardware & Foundry Co., Inc., Pa (a,b,c)
Lloyd & Scott Brass Foundry, Inc., Del (a,b)
Lodge Mfg. Co., Tenn (c)
Lodi Iron Works, Inc., Calif (c)
Loeffler, J.M. Co., Machine & Brass Works, Pa (b)
Long Beach Iron Works, Calif (c)
Long Foundry Co., Wash (c)
Lorain Brass Co., Ohio (b)
Los Angeles Steel Casting Co., Calif (g)
Ludlow Valve Mfg. Co., Inc., NY (c)
Lumen Bearing Co., NY (b,d,j)
Lynchburg Foundry Co., Castings Div., Va (c)
Macaulay, H.C. Foundry Co., Calif (c)
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa (g)
Madison Foundry Co., Ohio (c)
Magline, Inc., Mich (a,e)
Mallory, P.R. & Co., Inc., Ind (b,f,h)
Manco Products Inc., Mich (b)
Mansfield Brass & Aluminum Corp., Ohio (a,b)
Marshall Car Wheel & Foundry Co., Inc., Tex (c)
Massillon Steel Casting Co., Ohio (g)
McLanahan & Stone Corp., Pa (c)
McNally Pittsburgh Mfg. Co., Kan (c)
Meadville Malleable Iron Co., Pa (c)
Meehanite Metal Corp., NY (c)—Ad pp 378, 379
Merrimac Brass, Mass (a,b,d,e,f)
Merriman Bros., Inc., Mass (b)
Metal Goods Corp., Mo (f)
Metropolitan Iron Foundry, NY (a,c)
Midwest Foundry Co., Div. of L.A. Darling Co., Mich (c,g)
Midwestern Foundries, Inc., Ind (c)
Milwaukee Aluminum & Brass Foundry, Wis (a,b)
Milwaukee Malleable & Grey Iron Works, Wis (c)
Milwaukee Valve Co., Wis (a,b)
Minneapolis Electric Steel Castings Co., Minn (g)
Missouri Steel Castings Co., Mo (g)
Moccasin Bushing Co., Tenn (a)
Model Brass Co., Inc., Ill (a,b)
Modern Brass Foundry & Mfg. Co., Ohio (a,b)
Moline Malleable Iron Co., Ill (c)
Monroe Steel Castings Co., Mich (g)
Montague Machine Co., Mass (b,c,f)
Moore Dry Dock Co., Calif (b,g)
Morrisville Foundry Co., Inc., Vt (c)
Morse, Fred W. Co., RI (a,j)
Mount Vernon Furnace & Mfg. Co., Ill (c)
Mueller Brass Co., Mich (a,b)—Ad p 397
Muskegon Piston Ring Co., Mich (b,c)
National Aluminum Co., Inc., Wis (a,b)
National Aluminum & Brass Foundry, Inc., Mo (a,b)
National Bearing Div., American Brake Shoe Co., Pa (b)
National Brass Works, Inc., Calif (a,b,d,f)
National Grey Iron Foundry, Ill (c)
National Malleable & Steel Castings Co., Ohio (c,g)
National Steel & Shipbuilding Corp., Calif (c)
National Supply Co., Pa (g)
Neenah Foundry Co., Wis (c)
Newman Bros., Inc., Ohio (a,b)
Noble & Wood Machine Co., NY (c)
North Wales Foundry Co., Inc., Pa (c)
Northern Malleable Iron Co., Minn (c)
Nutmeg Crucible Steel Co., Conn (g)
Oak Hill Foundry & Machine Works, Ohio (c)
Oakes Bronze & Aluminum Co., Ohio (a,b)
Oakland Foundry & Machine Co., Mich (c)
Ohio Malleable Div., Dayton Malleable Iron Co., Ohio (c)
Ohio Precision Castings, Inc., Ohio (a,b,f)
Ohio Steel Foundry Co., Ohio (f,g)
Oil City Iron Works, Tex (c)
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla (g)
Olderman Mfg. Corp., Conn (b)
Olds Alloys Co., Calif (a,b,d,f)
Olympic Steel Works, Wash (g)
Omaha Steel Works, Neb (g)
Oregon Brass Works, Ore (a,b)
Overmyer Mould Co., Inc., Ind (c,f,g)
Owen Pattern Foundry & Mfg Co., Inc., Va (a,b)
Pacific Brass Foundry of San Francisco, Calif (a,b,d,f,j)
Pacific Foundry Co., Ltd., Calif (c,g)
Palmyra Foundry Co., Inc., NJ (c)
Parker, Charles Co., Conn (a,b)
Parker-Street Castings Co., Ohio (c)
Paulson, Thomas & Son, Inc., NY (a,b,f,j)
Payne, F.S. Co., Mass (c)
Pelton Steel Casting Co., Wis (g)
Penn Steel Castings Co., Pa (g)
Peoria Malleable Casting Co., Ill (c)
Pequonnock Foundry, Inc., Conn (c)
Perfecto Cast, Calif (f,g)
Perkins, Henry Co., Mass (c)
Permold Co., Ohio (a)
Pettibone Mulliken Corp., Ill (g)
Pittsburgh Foundry & Machine Co., Pa (c)
Pittsburgh Steel Foundry Corp., Pa (g)
Pohlman Foundry Co., Inc., NY (c)
Portland Iron Works, Ore (c)
Posey Iron Works, Inc., Pa (c,g)
Potts, C. & G. Co., Ind (c)
Pratt, William E. Mfg. Co., Ill (c)
Prescott Co., Mich (a,c)
Pusey & Jones Corp., Del (c)
Quaker Alloy Casting Co., Pa (c,f,g)
Quality Electric Steel Castings, Inc., Tex (g)
Quest, J.F. Foundry Co., Minn (c)
Quincy Steel Casting Co., Mass (g)
Racine Steel Castings Co., Belle City Malleable Iron Div., Wis (c)
Refinery Castings Co., Tex (g)
Reliance Foundry Co., Ohio (c)
Rensselaer Valve Co., NY (c)
Richmond Foundry & Mfg. Co., Inc., Va (a,b,c,d,f,j)
Ridge Foundry, Calif (c)
Riverside Foundry & Galvanizing Co., Mich (a,b,c,f)
Rolle Mfg. Co., Pa (a,e)
Rosedale Foundry & Machine Co., Pa (c)
Ross-Meehan Foundries, Tenn (c,g)
Saginaw Bearing Co., Mich (a,b)
St. Louis Malleable Casting Co., Mo (c)
St. Louis Steel Casting, Inc., Mo (g)
St. Marys Foundry Co., Ohio (c)
Sall Bros. Co., Ill (a,b)
San Francisco Iron Foundry, Calif (a,c)
Sandy Hill Iron & Brass Works, NY (a,b,c)
Saran Lined Pipe Co., Mich (c,g)
Sargent & Greenleaf, Inc., NY (a,b)
Savannah Machine & Foundry Co., Foundry Div., Ga (a,b,c,d)
Schaefer-Goodnow Foundries, Inc., Pa (c)
Schilling Bronze Co., NY (a,b,d,f,j)
Schmeller Aluminum Foundry Co., Ohio (a)
Schneider, Bowman Co., Inc., Pa (c)
Scottdale Ozone Co., Pa (a,c)
Scovill Mfg. Co., Mill Products Div., Conn (b)
Scudder, E. J. Foundry & Machine Co., NJ (f,g)
Scullin Steel Co., Mo (g)
Selma Foundry & Machine Co., Ala (c)
Sequoia Metalcraft Co., Inc., Calif (e)
Shakopee Foundry Co., Minn (c)
Sharpsville Steel Fabricators, Inc., Pa (c,g)
Shartle Div., Black-Clawson Co., Ohio (a,b,c)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Sheffield Foundry Co., Ill (c)
Shenango Furnace Co., Ohio (c)
Sherman & Reilly, Inc., Tenn (a,c,g)
Shriver, T. & Co., Inc., NJ (a,b,c,d)
Sibley Machine & Foundry Corp., Ind (c)
Sillcocks Miller Co., NJ (b,j)
Sinclair Co., Mass (a,b)
Sioux City Foundry & Boiler Co., Iowa (a,c)
Sivyer Steel Casting Co., Wis (g)
Smith, A.P. Mfg. Co., NJ (c)
Smith & Winchester Mfg. Co., Conn (a,b,c,g)
Solon Foundry, Inc., Ohio (a,b,e)
Somerset Foundry & Machine Co., Pa (a,c,d)
Sonith Foundries, Food Machinery Corp., Ind (b,c)
Sorbo-Cast Corp., NJ (c)
Sorbo-Mat Process Engineers, Mo (c)
Southern Metal Products Co., La (a)
Sparta Foundry Div., Muskegon Piston Ring Co., Mich (b,c)
Spencer's, I.S. Sons, Inc., Conn (a,b,c)
Spring City Foundry Co., Pa (c)
Springer's Foundry Co., Inc., Ind (a,c)
Springfield Foundry Co., Mass (c)
Spuck Iron & Foundry Co., Mo (c)
Stainless Foundry & Engineering, Inc., Wis (f,g)
Standard Casting Corp., Ill (a,b,d)
Standard Foundry Co., Mass (c)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (g)
Star Heel Plate Co., Inc., NJ (c,g)
State Foundry & Machine Co., Wis (c)
Stearns-Roger Mfg. Co., Colo (c)
Sterling Brass Foundry, Inc., Ind (a,b)
Sterling Foundry Co., Inc., Ill (a,b,c)
Sterrit-Thomas Foundry Co., Pa (c)
Stillman White Foundry Co., Inc., RI (a,b,d)
Strong Steel Foundry Co., NY (g)
Stuart Foundry Co., Mich (c)
Stulz-Sickles Co., NJ (g)
Superb Light Alloys, Inc., NY (a,e)
Superior Foundry, Inc., Ohio (c,g)
Swayne-Robinson & Co., Ind (a,c)
Swedish Crucible Steel Co., Mich (g)
Swett, A.L. Iron Works, NY (c)
Taylor & Co., Inc., NY (c)
Taylor & Boggis Foundry, Ohio (c)
Taylor-Wharton Co., Div. of Harsco Corp., NJ (g)
Terre Haute Bronze & Brass Foundry, Ind (b)
Terre Haute Malleable & Mfg. Corp., Ind (c)
Texas Foundries, Inc., Tex (c,g)
Thys Co., Calif (g)
Tower Grove Foundry, Mo (c)
Trenton Brass Co., NJ (b)
True Alloys, Inc., Mich (a,b,d,f,j)
Turner & Seymour Mfg. Co., Conn (c)
Union Iron Works, Wash (c,g)
Unitcast Corp., Ohio
(g)—Ad p 392
U.S. Pipe and Foundry Co., Ala (c)
Uniworld Research Corp. of America, Ohio (c,f)
Utica General Jobbing Foundry, Inc., NY (c)
Utica Radiator Corp., NY (c)
Valley Iron Works, Inc., Minn (c)
Valley Steel Casting Co., Mich (g)
Viking Pump Co., Iowa (c)
Vollrath Co., Wis (a,b,g)
Vulcan Foundry Co., Calif (c)
Vulcan Rail & Construction Co., NY (a,c,g)
Wagner Malleable Iron Co., Ill (c)
Wall Colmonoy Corp., Stainless Process Div., Mich
(c,f)
Waltham Foundry Co., Mass (a,c)
Washington Iron Works, Wash (c)
Waterman Industries, Inc., Calif (a,b,c)
Waukesha Foundry Co., Wis
(a,b,f,g)—Ad p 422
Wayne Agricultural Works, Inc., NC (b,c)
Wayne Foundry & Stamping Co., Mich (d,j)
Weber-Knapp Co., NY (a)
Webster Mfg. Inc., Ohio (c)
Wellman Bronze & Aluminum Co., Ohio (a,e)
Werner Foundry & Machine Co., Pa (c)
West Haven Foundry Co., Conn (a,b,d,f,j)
West Point Foundry & Machine Co., Div. of Batson-Cook Co., Ga (a,c,d)
West Steel Casting Co., Ohio (f,g)
Western Automatic Machine Screw Co., Ohio (c)
Western Foundry & Machine Works, Inc., Kan (c)
Western Iron & Foundry Co., Inc., Kan (c)
Westlectric Castings, Inc., Calif (g)
Westmoreland Malleable Iron Co., NY (c)
Whitehead Metal Products Co., Inc., NY (f)
Williams, A.C. Co., Ohio (e)
Williams, E.A. & Son, NJ (a,b)
Winters Foundry & Machine Co., Inc., Ohio (a,b,d,f,j)
Wisconsin Aluminum Foundry Co., Inc., Wis (a,b)
Wollaston Foundry Corp., Mass (c)
Woodruff & Edwards, Inc., Ill (c)
Worthington Corp., NJ (c)
Zenith Foundry Co., Wis (c)

Castings, Shell Mold

Abco Aluminum & Brass Works, Tex (a,b,d,f,j)
Aelco Foundries, Inc., Wis (a,b,f,g)
Albion Malleable Iron Co., Mich (c)
Alloy Precision Castings Co., Ohio (a,b,c,e,f,g)
Alloy Steel Casting Co., Pa (f,g)
Almont Mfg. Co., Mich (c)
American Aluminum Casting Co., NJ (a)
American Cast Iron Pipe Co., Ala
(c)
American Manganese Steel Div., American Brake Shoe Co., Ill
(g)
American Steel Foundries, Ill (g)
Ampco Metal, Inc., Wis (b)
Atlas Foundry & Mfg. Co., Calif (a,b,c,g)
Aurora Metal Co., Ill (b)
Austenal Co., Div. of Howe Sound Co., NY (a,c,f,g)
Auto Specialties Mfg. Co., Mich (g)
Baxter Foundry & Machine Works, Inc., Ind (c)
Bendix Foundries Div., Bendix Aviation Corp., NJ (a,e)
Bethlehem Steel Co., Pa (g)
Blaw-Knox Co., Pa (f,g)
Buckeye Brass & Mfg. Co., Ohio (a,b)
Cadillac Malleable Iron Co., Mich (c)
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich (c)
Castalloy Co., Inc., Mass (a,e)
Chicago Hardware Foundry Co., Ill (a,b,c)
Chicago Malleable Castings Co., Ill (c)
Cochrane Foundry, Inc., Pa (a,b,j)
Cooper Alloy Corp., NJ (g)
Crucible Steel Casting Co., Pa (g)
Curtiss-Wright Corp., Metals Processing Div., NY (f,g)
Dayton Malleable Iron Co., Ohio (c)
Dirilyte Co. of America, Inc., Ind. (b)
Duraloy Co., Pa
(f)—Ad p 401
Eaton Mfg. Co., Foundry Div., Mich (c)
Electric Steel Foundry Co., Ore (f,g)
Electro-Alloys Div., American Brake Shoe Co., Ohio (g)
Electron Corp., Colo (c)
Emmaus Foundry & Machine Co., Pa (a,b,c)
Empire Steel Castings, Inc., Pa (g)
Erie Casting Co., Pa (c)
Fischer Casting Co., Inc., NJ (a)
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa (f,g)
Foster Aluminum Alloy Products Corp., NY (a)
Gale Mfg. Co., Mich (c)
General Electric Co., Foundry Dept., NY (f,g)
General Motors Corp., Central Foundry Div., Mich (c)
General Motors Corp., Fabricast Div., Ind (a)
Gilbert Brass Foundry Co., Mo (a,b)
Grimm Foundry Co., Inc., NJ (c)
Gunite Foundries Corp., Ill (c,g)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f)
Hica, Inc., La (g)
Hobbs, Clinton E. Co., Mass (a,b,c)
Howard Foundry Co., Ill (a,b,c,e,f,g)
Investment Casting Co., NJ (a,b,c,f,g)
Ironton Malleable Div., Dayton Malleable Iron Co., Ohio (c)
Jamestown Malleable Iron Corp., NY (c)
Laconia Malleable Iron Corp., NH (c)
Lakeside Malleable Casting Co., Wis (c)
Lebanon Steel Foundry, Pa
(g)—Ad p 402
Lehigh, Inc., Pa (c)
Liberty Foundry Co., Mo (c,g)
Light Metals Dept., American Brake Shoe Co., NJ (a)
Loeffler, J.M. Co., Machine & Brass Works, Pa (b)
Lumen Bearing Co., NY (b)
Lynchburg Foundry Co., Castings Div., Va (c)
Mallory, P.R. & Co., Inc., Ind (b)
Marshall Car Wheel & Foundry Co., Inc., Tex (c)
Massillon Steel Casting Co., Ohio (g)
McCarter Iron Works, Inc., Pa (c,g)
Meehanite Metal Corp., NY
(c)—Ad pp 378, 379
Mercast Mfg. Corp., Calif (a,b,c,e,f,g)
Metal Goods Corp., Tex (c,f)
Michigan Steel Casting Co., Div. of Consolidated Foundries & Mfg. Corp., Mich (g)
Midwest Foundry Co., Div. of L.A. Darling Co., Mich (c,g)
Misco Precision Casting Co., Mich (c,f,g)
Missouri Diecasting Co., Mo (a,b,c,g)
National Bearing Div., American Brake Shoe Co., Pa (b)
National Lead Construction Co., Inc., NJ (d)
National Malleable & Steel Castings Co., Ohio (c)
Northern Malleable Iron Co., Minn (c)
Ohio Steel Foundry Co., Ohio (f,g)
Oklahoma Steel Casting Div., American Steel & Pump Corp., Okla (g)
Olderman Mfg. Corp., Conn (j)
Olympic Steel Works, Wash (g)
Oregon Brass Works, Ore (a,b)
Pacific Brass Foundry of San Francisco, Calif (a,b,f,j)
Parker, Charles Co., Conn (a,b)
Pelton Steel Casting Co., Wis (f,g)
Perfecto Cast, Calif (f,g)
Pettibone Mulliken Corp., Ill (g)
Pratt & Letchworth Div., Dayton Malleable Iron Co., Inc., NY (g)
Precision Castparts Corp., Ore (a,b,f,g)
Pusey & Jones Corp., Del (c)
Quaker Alloy Casting Co., Pa (c,f,g)
Racine Steel Castings Co., Belle City Malleable Iron Div., Wis (c,g)
Ridge Foundry, Calif (c)
Rolle Mfg. Corp., Pa (a,e)
Ross-Meehan Foundries, Tenn (c,g)
Sall Bros. Co., Ill (a,b)
Schilling Bronze Co., NY (a,b,d)
Sorbo-Mat Process Engineers, Mo (c)
Spencer's, I.S. Sons, Inc., Conn (c)
Star Heel Plate Co., Inc., NJ (a,b,c,g)
State Foundry & Machine Co., Wis (c)
Superb Light Alloys, Inc., NY (a,e)
Taylor & Co., Inc., NY (c)
Texas Foundries, Inc., Tex (c,g)
Trenton Brass Co., NJ (b)
True Alloys, Inc., Mich (a,b,d,f,j)
Unitcast Corp., Ohio
(g)—Ad p 392
Uniworld Research Corp. of America, Ohio (c,f)
Utica General Jobbing Foundry, Inc., NY (c)
Utility Steel Foundry, Calif (c,g)
Vanadium-Alloys Steel Co., Pa (g)
Wall Colmonoy Corp., Stainless Process Div., Mich
(c,f)
Washington Iron Works, Wash (c)
Waterman Industries, Inc., Calif (b,c)
Waukesha Foundry Co., Wis
(a,b,f,g)—Ad p 422
Wayne Agricultural Works, Inc., NC (b,c)
West Steel Casting Co., Ohio (f,g)
Western Automatic Machine Screw Co., Ohio (c)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
(a,b,c,f,g,h)
Winters Foundry & Machine Co., Inc., Ohio (a,b,d,f,j)
Woodruff & Edwards, Inc., Ill (c)
Zenith Foundry Co., Wis (c)

Cellophane

(see Cellulose, Regenerated)

Cellulose Acetate

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Albany Novelty Mfg. Co., Mass (t)
American Hard Rubber Co., Div. of Amerace Corp., NJ
(bb,dd,ee)
American Products Mfg. Co., La (t)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Auburn Plastic Engineering, Ill (bb,cc)
Auburn Plastics, Inc., NY (bb,dd,ee)
Bamberger, Claude P., Inc., NJ (p,y)
Blank, Arthur & Co., Inc., Mass (t,cc)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Carroll, J.B. Co., Ill (cc)
Carroll Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Celanese Plastics Co., Div. of Celanese Corp. of America, NJ
(p,s,t,y,cc)—Ad pp 219-226
Celluplastic Corp., NJ (bb,ee)
Chemical Development Corp., Mass (p)
Chicago Molded Products Corp., Campco Div., Ill (t,cc)
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., Ill (t,bb,cc,dd,ee)
Comco Plastics, Inc., NY (cc,dd)
Commercial Plastics & Supply Corp., NY (bb,cc,ee)
Craftint Mfg. Co., Ohio (cc)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (cc)
Davis, Joseph Plastics Co., NJ (t,y,bb,cc,dd,ee)
Denver Plastics, Inc., Colo (u)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)

du Pont de Nemours, E.I. & Co., Inc., Del
(p,s,cc,)
Dura Plastics of New York, Inc., NY (cc)
Dyna-Therm Chemical Corp., Calif
(p)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., Tenn
(p,y)
Eastman Kodak Co., Cellulose Products Sales Div., NY (t,cc)
Eljay Corp., Md (cc)
Falge Engineering Corp., Md (t)
Fry Plastics Co., Calif (t,cc)
General Gasket, Inc., Conn (t,cc)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Gering Products, Inc., NJ (y)
Glass Laboratories, NY (bb,dd)
Gomar Mfg. Co., Inc., NJ (cc)
Hastings & Co., Inc., Pa (t)
Industrial Plastics Corp., Ind (bb,dd)
Insulation Mfrs. Corp., Ill (t,cc,dd)
Jet Specialties Co., Inc., Calif (bb,cc,dd,ee)
Knoedler Chemical Co., Pa (bb,cc)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc)
Midwest Plastic Products Co., Ill (t,cc)
Monsanto Chemical Co., Plastics Div., Mass (t)
Muehlstein, H. & Co., Inc., NY (y)
National Gasket & Washer Mfg. Co., Inc., NY (cc,dd)
New England Tape Co., Inc., Mass (bb,cc)
Nixon Nitration Works, NJ (bb,cc,ee)
Norrich Plastics Corp., NY (bb,cc,ee)
Omni Products Corp., NY (y,bb,cc)
Ormond Mfg. Co., Inc., NJ (cc,dd)
Pacific Coast Foil Co., Calif (t)
Panelyte Div., St. Regis Paper Co., NY (cc)
Perfex Plastics, Inc., (bb,dd,ee)
Philrus Products Co., NJ (cc,dd)
Plast-Ad Mfg. Co., Ind (cc)
Plastic Materials, Inc., NY (y)
Precision Paper Tube Co., Ill (ee)
Pyramid Plastics, Inc., Ill (dd,ee)
Reed Plastics Corp., Mass (y)
Rosco Laboratories, NY (cc)
Rowland Products, Inc., Conn (x,bb,cc,dd,ee)
Russell Mfg. Co., Conn (s)
Schwab Plastic Corp., Mich (u,bb,cc,dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Simon Products Co., Ill (t,cc)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Stone Paper Tube Div., Stone Straw Corp., Washington, DC (ee)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd,ee)
Western Felt Works, Ill
(cc)
Westlake Plastics Co., Pa (bb,cc,dd,ee)
World Plastics, NY (bb,cc,dd,ee)

Cellulose Acetate Butyrate

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Albany Novelty Mfg. Co., Mass (t,cc)
American Hard Rubber Co., Div. of Amerace Corp., NJ
(bb,dd,ee)
American Molding Powder & Chemical Co., NY (y)
Anchor Plastics Co., Inc., NY
(bb,dd,ee)
Anderson Assoc., Inc., Ohio (y)
Anesite Co., Ill (ee)
Auburn Plastic Engineering, Ill (t,bb,cc,ee)
Auburn Plastics, Inc., NY (bb,cc,dd,ee)
Bamberger, Claude P., Inc., NJ (p,y)
Bischoff Chemical Corp., NY (u)
Blank, Arthur & Co., Inc., Mass (t,cc)
Busada Mfg. Corp., NY
(ee)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Carroll, J.B. Co., Ill (cc)
Carroll Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Celluplastic Corp., NJ (bb,ee)
Chicago Molded Products Corp., Campco Div., Ill (t,cc)
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., Ill (t,bb,cc,ee)
Columbus Coated Fabrics Corp., Ohio (u)
Comco Plastics, Inc., NY (cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Davis, Joseph Plastics Co., NJ (t,y,bb,cc,dd,ee)
Denver Plastics, Inc., Colo (u)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Durable Form Products, Inc., NY (cc,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., Tenn
(p,y)
Eastman Kodak Co., Cellulose Products Sales Div., NY (t,cc)
Falge Engineering Corp., Md (t)
Fidelity Chemical Products Corp., NJ (u)
Fry Plastics Co., Calif (t,cc)
General Gasket, Inc., Conn (t,cc)
General Plastics Corp., Ind (cc)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Gering Products, Inc., NJ (y)
Glass Laboratories, NY (bb,dd)
Gomar Mfg. Co., Inc., NJ (cc)
Grigoleit Co., Ill (p,s)
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
Jet Specialties Co., Inc., Calif (bb,cc,dd,ee)
K S H Plastics, Inc., Mo (bb,cc,dd)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc)
Midwest Plastic Products Co., Ill (t,cc)
Muehlstein, H & Co., Inc., NY (y)
New England Tape Co., Inc., Mass (bb,cc)
Nixon Nitration Works, NJ (bb,cc,ee)
Omni Products Corp., NY (y,bb,cc)
Panelyte Div., St. Regis Paper Co., NY (cc)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Precision Paper Tube Co., Ill (ee)
Pyramid Plastics, Inc., Ill (dd,ee)
Rowland Products, Inc., Conn (x,bb,cc,dd,ee)
Schwab Plastic Corp., Mich (u,bb,cc,dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Shoe Form Co., Inc., NY (cc,dd,ee)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd,ee)
Western Felt Works, Ill
(cc)
Western Plastics Corp., Neb (bb,dd,ee)
Westlake Plastics Co., Pa (bb,cc,dd,ee)
World Plastics, NY (bb,cc,dd,ee)

Cellulose Nitrate

Adhesive Products Corp., NY (x)
Chemical Development Corp., Mass (p)
Columbus Coated Fabrics Corp., Ohio (u)
Crescent Plastics, Inc., Ind (ee)
du Pont de Nemours, E.I. & Co., Inc., Del
(p,cc)
Falge Engineering Corp., Md (t)
General Gasket, Inc., Conn (t)
Hercules Powder Co., Inc., Del
(p)
Nixon Nitration Works, NJ (bb,cc,ee)
Omni Products Corp., NY (bb,cc)
Panelyte Div., St. Regis Paper Co., NY (cc)
Rowland Products, Inc., Conn (x,cc)
Wasco Products, Inc., Mass (cc)
Western Felt Works, Ill
(cc)

Cellulose Propionate

aaRBee Plastic Co., Calif (y)
Adhesive Products Corp., NY(x)
American Hard Rubber Co., Div. of Amerace Corp., NJ
(bb,ee)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Anderson Assoc., Inc., Ohio (y)
Celanese Plastics Co., Div. of Celanese Corp. of America, NJ
(p,y)—Ad pp 219-226
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., Tenn
(y)
Panelyte Div., St. Regis Paper Co., NY (cc)
Perfex Plastic, Inc., Ill (bb,dd)
Southern Plastics Co., SC (bb,cc,dd,ee)
Superior Plastics, Inc., Ill (ee)
World Plastics, NY (bb,cc,dd,ee)

Cellulose, Regenerated

(e.g., Cellophane)

Adhesive Products Corp., NY (x)
American Viscose Corp., Pa (t)
Blank, Arthur & Co., Inc., Mass (t)
Cadillac Plastic & Chemical Co., Mich (t)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
du Pont de Nemours, E.I. & Co., Inc., Del
(s,t,cc)
Foss Mfg. Co., Plastics Div., Id (t)
Mason Envelope Co., Inc., NY (t)
Olin Mathieson Chemical Corp., Packaging Div., NY (t)
Pacific Coast Foil Co., Calif (t)

Cemented Carbides

(see Cermets)

Centrifugal Castings

(see Castings)

Ceramic Coatings

(see Inorganic Coatings)

Ceramics

Adamas Carbide Corp., NJ (r)
Alite Div., U.S. Stoneware, Ohio (r)
American Lava Corp., Tenn (r,z,bb,ff)
Amersil Quartz Div., Engelhard Industries, NJ
(r)—Ad p 34
Arnold Engineering Co., Ill (r)
Beryl Ores Co., Colo (aa)
Brush Beryllium Co., Ohio
(r,aa,bb,ee)
California Metal Enameling Co., Calif (r)
Carborundum Co., NY (r,z,bb,cc,ee)
Carborundum Co., Refractories Div., NJ (s)
Centralab Div., Globe Union, Inc., Wis
(r,u,z,bb,ee)—Ad p 291
Commercialores, Inc., SC (aa)
Continental Coatings Corp., Ohio (aa)
Coors Porcelain Co., Colo (r,z,bb,cc,ee)
Diamonite Products Mfg. Co., Ohio (r,bb,cc,ee)
Du-Co Ceramics Co., Pa (r,z,aa,bb,ee)
Edgar Plastic Kaolin Co., Fla (aa)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Electric Auto-Lite Co., Ohio (r)
Electrical Refractories Co., Ohio (r,bb, ee)
Electro Chemical Engineering & Mfg. Co., Pa (r)
Electro Refractories & Abrasives Corp., NY (r)
Emerson & Cuming, Inc., Mass (r,u)
Foote Mineral Co., Pa (aa)
Frenchtown Porcelain Co., NJ (r,bb, cc,ee)
General Ceramics Corp., NJ (r,u,z,aa, bb,cc,ee)
Gladding, McBean & Co., Calif (r,z, bb,cc,ee)
Glass Laboratories, NY (r)
Gulton Industries, Inc., NJ (r)
Industrial Tectonics, Inc., Mich (r)
Knight, Maurice A., Ohio (r)
Laboratory Equipment Corp., Mich (r, z,bb,cc,ee)
Louthan Mfg. Co., Div. of Ferro Corp., Ohio (r,z,bb,cc,ee)
Malvern Brick & Tile Co., Ark (r)
Mansol Ceramics Co., NJ (r)
McDanel Refractory Porcelain Co., Pa (r,bb,cc,ee)—Ad p 292
Metal & Thermit Corp., NJ (aa)
Metallizing Engineering Co., Inc., NY (aa)
Metallizing Co. of Los Angeles, Inc., Calif (bb)
Mica Fabricating Co., NJ (r,u,z,bb,cc, ee)
Morganite, Inc., NY (r,aa,bb,ee)
Mycalex Corp. of America NJ (r,bb)—Ad p 303
National Beryllia Corp., NJ (r)
Norton Co., Mass (r,aa,bb,ee)—Ad p 287
Nuclear Metals, Inc., Mass (r,bb,cc, ee)
Porcelain Products, Inc., Ohio (r,s,z, bb,ee)
Pyrosil, Inc., Ohio (r,aa,bb,cc,ee)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (r)
Refractory & Insulation Corp., NY (r, aa)
Russell Mfg. Co., Conn (r,s)
St. Eloi Corp., Ohio (r,z,aa)
Sauereisen Cements Co., Pa (aa)
Saxonburg Ceramics, Pa (r,z,aa,bb,ff)
Silicocks Miller Co., NJ (r)
Stackpole Carbon Co., Pa (r)
Star Porcelain Co., NJ (r,z,bb,ee)
Steatite Div., American Lava Corp., Tenn (r,z,bb,ee)
Steward, D.M. Mfg. Co., Tenn (r)
Stupakoff Div., Carborundum Co., Pa (r,s,aa,bb)
Sylvania Electric Products, Inc., Parts Div., Pa (r)
Sylvester & Co., Ohio (r)
Thermal American Fused Quartz Co., NJ (r)
Thermal Refractories Corp., NJ (r,z, bb,cc,ee)
Thermo Materials, Inc., Calif (r,z,aa, bb,cc,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
U.S. Stoneware Co., Ohio (r)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (r)
Wisconsin Porcelain Co., Wis (r,ee)
Zirconium Corp. of America, Ohio (r, aa,bb,ee)

Cermets

Allegheny Ludlum Steel Corp., Pa (r)—Ad p 81
American Brakeblok Div., American Brake Shoe Co., Mich (r)
American Sinteel Corp., NY (r)
Brush Beryllium Co., Ohio (r,aa)
Carborundum Co., NY (r)
Climax Molybdenum Div., American Metal Climax, Inc., NY (r)
Continental Coatings Corp., Ohio (aa)
Emerson & Cuming, Inc., Mass (r,u)
Firth Sterling, Inc., Pa (r)
General Electric Co., Metallurgical Products Dept., Mich (r)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (r, u,aa)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (r)
Hommel, O. Co., Pa (aa)
Industrial Tectonics, Inc., Mich (r)
Kanthal Corp., Conn (bb)
Kennametal, Inc., Pa (r,aa,bb,ee)—Ad p 301
Metal Carbides Corp., Ohio (r)
Metal Hydrides, Inc., Mass (aa)
Metallizing Engineering Co., Inc., NY (aa)
Metallizing Co. of Los Angeles, Inc., Calif (bb)
Nuclear Metals, Inc., Mass (r,bb,cc, ee)
St. Eloi Corp., Ohio (r,z,aa)
Sintercast Corp. of America, NY (r)
Steatite Div., American Lava Corp., Tenn (r,z,bb,ee)
Sylvester & Co., Ohio (r)
Thermo Materials, Inc., Calif (r,z,aa, bb,cc,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (r,aa)
U.S. Stoneware Co., Ohio (r)

Chemical Conversion Coatings

(see Conversion Coatings)

Chlorinated Polyether

Hercules Powder Co., Inc., Del (y)
National Vulcanized Fibre Co., Del (bb,cc,ee)—Ad p 226

Chloroprene Rubber

(Neoprene)

Adhesive Products Corp., NY (x)
American Rubber Products Corp., Ind (u,bb,cc,dd,ee)
Atlas Mineral Products Co., Pa (c)
Auburn Rubber Co., Inc., Ind (cc)
Automotive Rubber Co., Inc., Mich (cc, dd)
Belko Corp., Md (y)
Brown Rubber Co., Inc., Ind (u)
Capac Mfg. Corp., Mich (y,cc)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (x,y)
Chicago Rubber Co., Inc., Ill (u,y)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (y,cc,dd)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Coyne & Paddock, Inc., NY (cc)
Dayton Rubber Co., Ohio (y,bb,cc, dd,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I. & Co., Inc., Del (p)
Dutch Brand Div., Johns-Manville Corp., Ill (u,y,cc,dd)
Dyna-Therma Chemical Corp., Calif (p)
Electro Chemical Engineering & Mfg. Co., Pa (t.cc)
Faultless Rubber Co., Ohio (u,y,bb, ee)
Flexfirm Products, Calif (s)
Flexible Tubing Corp., Conn (ee)
Foamade Industries, Mich (u)
Garlock Packing Co., NY (y,bb,cc,dd, ee)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Co., Conn (u)
Goshen Rubber Co., Inc., Ind (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Knight, Maurice A., Ohio (cc)
Maloney, F.H. Co., Tex (y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,x,y)
Paeco Rubber Co., Inc., Ohio (y,dd, ee)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Polymer Chemical Co., Ohio (x)
Raybestos - Manhattan, Inc., Plastic Products Div., Conn (x)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,cc,dd,ee)
Rogers Corp., Conn (u,y,cc,dd)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries, Inc., Va (u)
Sheller Mfg. Corp., Mich (u)
Snyder, M.L. & Son, Inc., Pa (cc,ee)
Standard Products Co., Mich (y)
Stockwell Rubber Co., Inc., Pa (u,y, bb,cc,dd)
Technical Specialties Co., NY (dd)
Toyad Corp., Pa (u)
Trostel, Albert Packing Ltd., Wis (y)
U.S. Rubber Co., Kem-Blo Dept., Conn (u)
U.S. Stoneware Co., Ohio (y)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams - Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Chlorosulfonated Polyethylene Rubber

Adhesive Products Corp., NY (x)
Allis Rubber Div., Chicago-Allis Mfg. Corp., Ill (p)
Atlas Mineral Products Co., Pa (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (x,y)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E. I. & Co., Inc., Del (p)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Flexfirm Products, Calif (s)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Maloney, F.H. Co., Tex (y)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Prince Rubber Co., Inc., NY (cc,ee)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p)
Rogers Corp., Conn (cc,dd)
Toyad Corp., Pa (t)
Trostel, Albert Packing, Ltd., Wis (y)
Vulcan Rubber Products Div., Reeves Bros., Inc, NY (p,y,cc)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Chlorotrifluoroethylene

(see Fluorocarbon)

Chromate Coatings

(see Conversion Coatings)

Chromium

Alloy Metal Powder, Inc., Iowa (aa)
Alloy Metal Products, Inc., Iowa (o,w)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Arcos Corp., Pa (ff)
Belmont Smelting & Refining Works, Inc., NY (w,aa)
Chicago Development Corp., Md (aa)
Dahlin, C.A. Co., Ill (cc,ee)
Driver, Wilbur B. Co., NJ (v,bb,dd,ff)—Ad p 153
Foote Mineral Co., Pa (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (aa)
Hull, R.O. & Co., Inc., Ohio (n)
K. & L. Plating Co., Pa (z)
Kawecki Chemical Co., NY (aa)
Lakeland Industries, Minn (z)
Metal Hydrides, Inc., Mass (aa)
Metal & Thermit Corp., NJ (w)
Metals Disintegrating Co., Inc., NJ (aa)—Ad p 415
Michigan Seamless Tube Co., Mich (ee)
Modern Plating Corp., Ill (n)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Nuclear Metals, Inc., Mass (w,bb,dd, ee)
Republic Steel Corp., Steel & Tubes Div., Ohio (ee)
Sel-Rex Corp., NJ (n)
Shieldalloy Corp., NJ (aa)
Stevens, Frederic B., Inc., Mich (n)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (w,aa)—Ad pp 144-145
Vanadium Corp. of America, NY (w)
Walmet Alloys Co., Mich (w)—Ad p 80
Westinghouse Electric Corp., Materials Mfg. Dept., Pa. (o,q,v,w,z,bb,cc,dd,ee)

Chromized Coatings

(see Diffusion Coatings)

Suppliers of Materials

Clad Metals

(key letters refer to base metals; see also Laminates, Metal-Metal)

Alabama Wire Co., Inc., Ala (a)
Al-Fin Div., Fairchild Engine & Airplane Corp., NY (a,e)
Allegheny Ludlum Steel Corp., Pa
(g)
Aluminum Co. of America, Pa (a)
American Silver Co., NY (b,c,f,g)
Arrow Metal Products Corp., NJ (a)
Bart Mfg. Corp., NJ (a,b,c,e,f,g,h)
Bartlett-Thompson Co., Inc., Mass (a, b,f)
Bishop, J. & Co. Platinum Works, Pa
(f,g)
Borg-Warner Corp., Ill (g)
Chicago Bridge & Iron Co., Ill (g)
Clad-Rex Corp., Ill
(a,g)
Copper & Brass Sales, Inc., Mich (a)
Darby Corp., Kan (a,f,g)
Driver-Harris Co., NJ
(f)
Electric Materials Co., Pa (c)
Electric Steel Foundry Co., Ore (f,g)
Electronic Parts Mfg. Co., NJ (b)
Enamel Products Co., Ohio (a,g)
Fromson Orban Co., Inc., NY (b,f,g)
General Alloys Co., Mass (f,g)
General Finding & Supply Co., Industrial Div., Mass (b)
General Plate Div., Metals & Controls Corp., Mass (a,b,c,e,f,g,h,j)
Improved Seamless Wire Co., RI (b,f)
Jessop Steel Co., Pa (g)
Johnson Bronze, Pa (a,b,d,g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kewaunee Engineering Corp., Wis (c)
Leach & Garner Co., Industrial Div., Mass (b,f)
Lukens Steel Co., Pa
(a,b,e,f,g,h)—Ad pp 76-77
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (b,c,f,g)
Manufacturers & Fabricators, Inc., Ohio (f,g)
Metal Goods Corp., Mo (f)
Metals & Controls Corp., Mass (a,b,c, f,g,h)
Moraine Products Div., General Motors Corp., Ohio (a,d)
National Galvanizing Co., Pa (g)
National Lead Co., NY (d)
National Lead Construction Co., Inc., NJ (d)
Nuclear Metals, Inc., Mass (a,b,c,e, f,g,h)
Olin Mathieson Chemical Corp., Aluminum Div., NY
(a)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Parish Pressed Steel Div., Dana Corp., Pa (a,g,j)
Pittsburgh Steel Co., Pa (b,f,g,j)
Republic Steel Corp., Ohio
(g)
Revere Copper & Brass, Inc., NY (b)
Reynolds Metals Co., Va (a)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ
(b,f)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Saginaw Bearing Co., Mich (b,g)
Sandy Hill Iron & Brass Works, NY (g)
Seattle Boiler Works, Inc., Wash (g)
Sharpsville Steel Fabricators, Inc., Pa (g)
Somers Brass Co., Inc., Conn
(f)
Standard Metals Corp., Mass (a,b,c, f,g)
Sun Steel Co., Ill (a,e,g)
Superior Steel Div., Copperweld Steel Co., Pa (g)
Sylvania Electric Products, Inc., Parts Div., Pa
(b,g)—Ad p 417
Werner, R.D. Co., Inc., NY (a,g)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
(f,g,h)
Whitehead Metal Products Co., Inc., NY (f)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (f,g)
Worcester Wire Works Div., National-Standard Co., Mass (g)

Claddings

(see Organic Coatings; Clad Metals)

Coated Metals

(see Precoated Metals)

Coatings

(see specific type)

Cobalt and Its Alloys

Alloy Metal Products, Inc., Iowa (o, w)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Austenal Co., Div. of Howe Sound Co., NY (w)
Belmont Smelting & Refining Works Inc., NY
(n,w,aa)
Cannon-Muskegon Corp., Mich (w)
Crobalt, Inc., Mich (n,w,bb)
Crucible Steel Co. of America, Titanium & Vacuum Metals Product Div., Pa (o,q,w,z,cc,dd)
Driver, Wilbur B. Co., NJ
(v,bb,dd,ff)—Ad p 153
Driver-Harris Co., NJ
(bb,dd)
Dudek & Bock Spring Mfg. Co., Ill (ff)
Elgin National Watch Co., Abrasives Div., Ill (o,bb,dd,ff)
Foote Mineral Co., Pa (aa)
General Plate Div., Metals & Controls Corp., Mass (v,dd)
Hamilton Watch Co., Precision Metals Div., Pa (v,w,bb,cc,dd)
Hardy, Charles, Inc., NY (aa)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (o,q,v,w,z,bb,cc, dd,ee,ff)
Hoskins Mfg. Co., Mich (bb,dd)
K. & L. Plating Co., Pa (z)
Kelsey-Hayes Co., Utica Metals Div., NY (o,q,v,w,z,bb,cc,dd,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o)
McGean Chemical Co., Ohio (aa)
Metal Hydrides, Inc., Mass (aa)
Michigan Seamless Tube Co., Mich (ee)
New Jersey Metals Co., NJ (w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Nuclear Metals, Inc. Mass (w)
Oregon Metallurgical Corp., Ore (w)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
(aa)
Utica Metals Div., Kelsey-Hayes Co., NY (o,q,v,w,z,bb,cc,dd,ff)
Vanadium-Alloys Steel Co., Pa (aa)
Walmet Alloys Co., Mich
(w)—Ad p 80
Wall Colmonoy Corp., Stainless Process Div., Mich
(w,bb)
Wallingford Steel Co., Conn (dd,ee)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
(o,q,v,w,z,bb,cc,dd,ee)

Cold Extrusions

(see Impact Extrusions)

Cold Headed Parts

Abbott Ball Co., Conn (b,g)
Acme Machine Products Div., Serrick Corp., Ind (g)
Albany Products Co., Inc., Conn (b,f)
Allied Products Corp., Mich (g)
Allmetal Screw Products Co., Inc., NY (f,g,h)
Aluminum Co. of America, Pa (a)
American Car & Foundry Div., ACF Industries, Inc., NY (g)
Ampco Metal, Inc., Wis (b)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Armco Steel Corp., Sheffield Div., Mo (g)
Art Wire & Stamping Co., NJ
(a,b,c,d,f,g)
Bead Chain Mfg. Co., Conn (a,g)
Bethlehem Steel Co., Pa (g)
Camcar Screw & Mfg. Co., Ill (a,g,h)
Central Screw Co., Ill (a,b,c,f,g)
Champion Rivet Co., Ohio (c,g)
Chandler Products Corp., Ohio (g)
Chicago Rivet & Machine Co., Ill (a, c,g)
Chicago Screw Co., Div. of Standard Screw Co., Ill (a,b,c,f,g)
Cincinnati Pump & Mfg. Co., Inc., Ohio (g)
Clark Bros. Bolt Co., Conn (a,b,c,g)
Clendenin Bros., Inc., Md (a,b,c)
Cleveland Cap Screw Co., Ohio (a, b,f,g,h)
Columbus Bolt & Forging Co., Ohio (a,b,g)
Deringer Metallurgical Corp., Ill (a, b,c,d,f,g)
Division Lead Co., Ill (d)
Eaton Mfg. Co., Reliance Div., Ohio (a,g)
Elco Tool & Screw Corp., Ill (a,b,c,g)
Electric Materials Co., Pa (b)
General Findings & Supply Co., Industrial Div., Mass (b,f)
Gibson Electric Co., Pa
(f)
Greene, G.G. Corp., Pa (g)
Grip Nut Co., Ind
(a,b,g)
Harper, H.M. Co., Ill (a,b,f,g)
Hartford Machine Screw Co., Div. of Standard Screw Co., Conn (a,b,c,f,g)
Hassall, John, Inc., NY (a,b,c,d,f,g)
Hercules Fastener Co., Ill (a,b,c,g,j)
Huck Mfg. Co., Mich (a,g)
Jaques Co., Mass (a,b,e,f,g,h)
Johnston & Funk Titanium Corp., Ohio (h)
Koehler Mfg. Co., Mass (c)
Lamson & Sessions Co., Ohio (a,b,c,f, g,h,)
McKinney Mfg. Co., Pa (a,b,c,d,f,g)
Metal Goods Corp., Mo (f)
Mid-West Screw Products Co., Mo (a, b,c,g)
Milford Rivet & Machine Co., Conn (a,b,c,g)
Murray Tube Works, Inc., NJ (a,b,j)
National Lock Co., Fastener Div., Ill (a,b,c,d,g)
National Screw & Mfg. Co., Ohio (a,b, f,g)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Pheoll Mfg. Co., Ill (a,b,c,g,h)
Plume & Atwood Mfg. Co., Conn (a,b, g)
Pusey & Jones Corp., Del (c)
Reed & Prince Mfg. Co., Mass (a, b,c,g)
Republic Steel Corp., Ohio
(g)
Russell, Burdsall & Ward Bolt & Nut Co., NY (a,b,g)
Scovill Mfg. Co., Mill Products Div., Conn
(a,b)
Shakeproof Div., Illinois Tool Works, Ill (a,b,g)
Standard Pressed Steel Co., Pa (a,b, f,g,h)
Thompson-Bremer & Co., Ill (a,b,c,f, g,h)
Torrington Co., Conn (b,g)
Townsend Co., Fasteners Div., Pa (a, b,g)
Tubular Rivet & Stud Co., Mass (a, b,c,f,g)
Union Screw & Mfg. Co., Pa (a,g)
United Screw & Bolt Corp., Ill (a,b,g)
United-Carr Fastener Corp., Mass (b,g)
Weatherhead Co., Ind (g)
Wesbar Stamping Corp., Wis (a,c,g)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (a,b,c,f,g)
Zeller Corp., Ohio (g)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Columbium and Its Alloys

American Silver Co., NY (v,dd,ee,ff)
Bishop, J. & Co. Platinum Works, Pa
(ee)
Bridgeport Brass Co., Conn
(ee)—Ad p 152
Damascus Tube Co., Pa
(ee)
Fansteel Metallurgical Corp., Ill
(n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad pp 158, 159
Hamilton Watch Co., Precision Metals Div., Pa (v,dd)
Hardy, Charles, Inc., NY (aa)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Kawecki Chemical Co., NY (o,q,v,w,z, aa,bb,cc,dd,ff)
Kennametal, Inc., Pa
(o,v,aa,dd)—Ad p 301
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,ee)
Mallory-Schwarzkopf Metals, Inc., NY (o,v,w,z,bb,cc,dd,ee,ff)
Metals & Controls Corp., Mass (v,dd)
Molybdenum Corp. of America, Pa (o, w,z,aa,bb,cc,dd)
Nuclear Metals, Inc., Mass (w,bb,dd, ee)
Oregon Metallurgical Corp., Ore (w)
Shieldalloy Corp., NJ (o,aa)
Techalloy Co., Inc., Pa (dd,ff)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
(w,aa)—Ad pp 144-145
United Screw & Bolt Corp., Ill (bb,cc, dd,ff)
Universal-Cyclops Steel Corp., Pa (o, q,z,cc)
Vanadium Corp. of America, NY
(w)
Wah Chang Corp., NY
(n,w,v,aa,bb,dd,ff)—Ad p 146
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
(o,q,v,w,z,bb,cc,dd,ee)

Composition Board

(see Wood)

Compression Moldings

(see Moldings)

Conversion Coatings, Anodic

(anodizers)

Abalon Precision Mfg. Corp., NY
Abco Aluminum & Brass Works, Tex
Accurate Anodizing Corp., Ill
Acme Plating Co., Ohio
Aerolite Extrusion Co., Ohio
Aluminum Billets, Inc., Ohio
Aluminum Finishing Corp., Ind
Aluminum Specialty Co., Wis
American Emblem Co., Inc., NY
Auld, D.L. Co., Ohio
B L C Porous Materials Co., Calif
B & T Metals Co., Ohio
Badger Aluminum Extrusions, NY
Biddle Screw Products Co., Ind
Bonnell, William L. Co., Inc., Ga
Briggs-Shaffner Co., NC
Brinkerhoff Brass & Bronze Works, Inc., NY
Brooks & Perkins, Inc., Mich
Chicago Thrift-Etching Corp., Ill
Colonial Alloys Co., Pa
Commercial Screw Products Co., Ohio
Corson Industries, Pa
Croname, Inc., Ill
Designers Metal Corp., Ill
Diversey Corp., Metal Industries Div., Ill
Doehler-Jarvis Div., National Lead Co., Ohio
Dollin Corp., NJ
Edna Lite Optical Co., Inc., NY
Engineering Products & Specialties, Inc., RI
Fox Co., Ohio
General Extrusions, Inc., Ohio
Hull, R.O. & Co., Inc., Ohio
Industrial Chromium Corp., Mass
Jarl Extrusions, Inc., NY
—Ad p 412
Kees, F.D., Mfg. Co., Neb
Kinkead Industries, Inc., Ill
Leed, H.A. Corp., Conn
Magnesium Co. of America, Ind
Magnesium Elektron, Inc., NY
Merz Machine & Tool Works, Ind
Metal Finishers, Inc., Md
Mirro Aluminum Co., Wis
Modern Plating Corp., Ill
National Aluminum Co., Ohio
National Galvanizing Co., Pa
National Gasket & Washer Mfg. Co., Inc., NY
Nylok Corp., NJ
Olean Electro Plating Co., NY
Reed & Prince Mfg. Co., Mass
Plume & Atwood Mfg. Co., Conn
Reynolds Metal Co., Va
Rustproofing & Metal Finishing Corp., Mass
Saramar Aluminum Co., Ohio
Schwartz Chemical Co., Inc., NY
Southern Aluminum Finishing Co., Inc., Ga
Spencer Nahm Co., Calif
Stevens, Frederic B, Inc., Mich
Trim Alloys, Inc., Mass
Udylite Corp., Mich
Vanamatic Co., Ohio
W L S Stamping Co., Ohio
Woodstock Div., Electric Auto-Lite Co., Ill
Youngstown Mfg. Inc., Ohio

Conversion Coatings, Chromate

(formulations)

Abalon Precision Mfg. Corp., NY
Acme Plating Co., Ohio
Allied Chemical Corp., Solvay Process Div. NY
—Ad p 329
Allied Research Products, Inc., Md
—Ad p 327
Amchem Products, Inc., Pa
—Ad p 337
Chemical Corp., Mass
Colonial Alloys Co., Pa
Conversion Chemical Corp., Conn
Diamond Alkali Co., Ohio
Dollin Corp., NJ
Enthone, Inc., Conn
Heatbath Corp., Mass
Hull, R.O. & Co., Inc., Ohio
MacDermid, Inc., Conn
Metal & Thermit Corp., NJ
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Nylok Corp., NJ
Oakite Products, Inc. NY
—Ad p 326
Octagon Process, Inc., NY
Parker Paint Mfg. Corp., Ind
Parker Rust Proof Co., Mich
Pierce & Stevens Chemical Corp., NY
Prestole Corp., Ohio
Promat Div., Poor & Co., Ill
Thompson & Co., Pa
Turco Products, Inc., Calif
Vanamatic Co., Ohio
Woodstock Div., Electric Auto-Lite Co., Ill
Zeller Corp., Ohio

Conversion Coatings, Chromate

(coaters)

Abalon Precision Mfg. Corp., NY
Accurate Anodizing Corp., Ill
Acme Plating Co., Ohio
Amchem Products, Inc., Pa
American Agile Corp., Ohio
American Emblem Co., Inc., NY
Brooks & Perkins, Inc., Mich
Clad-Rex Corp., Ill
Colonial Alloys Co., Pa
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Du-Wel Metal Products, Inc., Mich
Eaton Mfg. Co., Reliance Div., Ohio
Electrofilm, Inc., Calif
Falstrom Co., NJ
Farwell Metal Fabricating, Minn
Hardy Mfg. Corp., Ind
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Modern Plating Corp., Ill
Norgren-Stemac, Inc., Colo
Nylok Corp., NJ
Olean Electro Plating Co., NY
Prestole Corp., Ohio
Promat Div., Poor & Co., Ill
Rustproofing & Metal Finishing Corp., Mass
Sommer Metalcraft Corp., Ind
Spencer Nahm Co., Calif
United-Carr Fastener Corp., Mass
W L S Stamping Co., Ohio
Witt Cornice Co., Galvanizing Div., Ohio
Worth Co., Wis
Zeller Corp., Ohio

Conversion Coatings, Oxide

(formulations)

Birchwood Chemical Co., Minn
Dollin Corp., NJ
Du-Lite Chemical Corp., Conn
Enthone, Inc., Conn
Heatbath Corp., Mass
Houghton, E.F. & Co., Pa
Hull, R.O. & Co., Inc., Ohio
MacDermid, Inc., Conn
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Nylok Corp., NJ
Parker Paint Mfg. Corp., Ind
Prestole Corp., Ohio
Promat Div., Poor & Co., Ill
Tube Reducing Corp., NJ
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
Vanamatic Co., Ohio
Zeller Corp., Ohio

Conversion Coatings, Oxide

(coaters)

Biddle Screw Products Co., Ind
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Electric Auto-Lite Co., Ohio
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Metallizing Co. of Los Angeles, Inc., Calif
Modern Plating Corp., Ill
Nylok Corp., NJ
Plume & Atwood Mfg. Co., Conn
Prestole Corp., Ohio
Rustproofing & Metal Finishing Corp., Mass
Spencer Nahm Co., Calif
United-Carr Fastener Corp., Mass
W L S Stamping Co., Ohio
Worth Co., Wis

Conversion Coatings, Phosphate

(formulations)

Ainsworth Precision Castings Co., Div. of Harsco Corp., Mich
Amchem Products, Inc., Pa
—Ad p 337
Ashtabula Mfg. Co., Ohio
Detrex Chemical Industries, Inc., Mich
Dollin Corp., NJ
Enthone, Inc., Conn
Farrelloy Co., Pa
Fidelity Chemical Products Corp., NJ
Houghton, E.F. & Co., Pa
Hull, R.O. & Co., Inc., Ohio
Kelite Corp., NJ
MacDermid, Inc., Conn
Magnuson Products Corp., NY
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Northwest Chemical Co., Mich
Nylok Corp., NJ
Oakite Products, Inc., NY
—Ad p 326
Octagon Process Inc., NY
Panther Chemical Corp., Tex
Parker Rust Proof Co., Mich
Pennsalt Chemicals Corp., Pa
Plume & Atwood Mfg. Co., Conn
Prestole Corp., Ohio
Promat Div., Poor & Co., Ill
Rustproofing & Metal Finishing Corp., Mass
Sharon Steel Corp., Pa
Thompson & Co., Pa
Turco Products, Inc., Calif
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
Vanamatic Co., Ohio
Whitfield Chemical Co., Mich
Wyandote Chemicals Corp., Mich
Zeller Corp., Ohio

Conversion Coatings, Phosphate

(coaters)

Almco Steel Products Corp., Ind
Amchem Products, Inc., Pa
Ashtabula Mfg. Co., Ohio
Biddle Screw Products Co., Ind
Brandt, Charles T., Inc., Md
Clad-Rex Corp., Ill
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Electric Auto-Lite Co., Ohio
Electrofilm, Inc., Calif
Falström Co., NJ
Farwell Metal Fabricating, Minn
Grand Rapids Brass Co., Mich
Hardy Mfg. Corp., Ind
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Modern Plating Corp., Ill
National Metal Products Co., Pa
Nylok Corp., NJ
Prestole Corp., Ohio
Rustproofing & Metal Finishing Corp., Mass
Spencer Nahm Co., Calif
United Shoe Machinery Corp., Mass
United-Carr Fastener Corp., Mass
W L S Stamping Co., Chic
Witt Cornice Co., Galvanizing Div., Ohio

Woodstock Div., Electric Auto-Lite Co., Ill
Worth Co., Wis

Copper and Its Alloys

A & A Die Casting Co., Calif (cc)
Acme Tube, Inc., NJ (ee)
Ajax Metal Div., H. Kramer Co., Pa (w)
Alcasco Foundry, Ill (w)
Allied Research Products, Inc., Md
(n)—Ad p 327
Alloy Metal Products, Inc., Iowa (o,w)
Alofs Mfg. Co., Mich (dd)
Alpha Wire Corp., NY (ff)
American Brass Co., Sub. of Anaconda Co., NY
(n,o,v,z,bb,cc,dd,ee,ff)—Ad p 377
American Crucible Products Co., Ohio (o)
American Manganese Bronze Co., Pa (o,bb)
American Metal Climax, Inc., Amco Div., NY
(n,o,q,w,aa)—Ad pp 161-164
American Metal Climax Inc., NY (n, o,q,w,aa)
American Nickel Alloy Mfg. Corp., NY (o)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (n,q,w)
American Steel and Wire Div. U.S. Steel Corp., Ohio
(ff)
Ampco Metals, Inc., Wis (o,z,cc,dd,ee)
Anaconda Co., NY (n,q,v,w,cc)
Atlantic Steel Co., Ga (cc,dd)
Atlas Brass Foundry, Calif (o)
Auld, D.L. Co., Ohio (n,cc,dd,ff)
Avril, G.A. Co., Ohio (w)
Babson Dow Mfg. Co., Mass (o)
Bart Mfg. Corp., NJ (aa)
Barth Smelting Corp., NJ (w)
Bay State Refining Co., Inc., Mass (w)
Belmont Smelting & Refining Works, Inc., NY
(n,q,w,aa)—Ad p 159
Beryllium Corp., Pa
(o,q,w,z,bb,cc,dd,ee,ff)
Biddle Screw Products Co., Ind (bb,ee)
Bohn Aluminum & Brass Corp., Mich (bb,ff)
Both, O.A. Corp., Mass (aa)
Bridgeport Brass Co., Conn
(n,o,bb,cc,dd,ee,ff)—Ad p 152
Bridgeport Rolling Mills Co., Conn (dd)
Brinkerhoff Brass & Bronze Works, Inc., NY (z,bb,cc,dd,ee,ff)
Bristol Brass Corp., Conn (o,z,bb,cc, dd,ff)
Brush Beryllium Co., Ohio
(o,q,w,z,dd)—Ad p 149
Bullock, W.J., Inc., Ala (w)
Cerro de Pasco Sales Corp., NY
(w,ee,ff)
Chase Brass & Copper Co., Sub of Kennecott Copper Corp., Conn (n,o, z,bb,cc,dd,ee,ff)
Chicago Extruded Metals Co., Ill (bb)
Clark Perforating Co., Mich (cc,dd)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (ff)
Continuous Cast Products Dept., American Smelting & Refining Co., NJ
(o,q,bb,ee)—Ad pp 167-170
Copper & Brass Sales, Inc., Mich (n, o,q,v,z,bb,cc,dd,ee,ff)
Craft Metal Spinning Co., Ill (cc)
Crucible Steel Co. of America, Titanium & Vacuum Metals Product Div., Pa (o,q,w,z,cc,dd)
Dahlin, C.A. Co., Ill (z,cc,ee)
Designers Metal Corp., Ill (cc)
Detroit Float & Stamping Co., Mich (o,bb,dd,ee)
Dixon Sintaloy, Inc., Conn (o)
Dormont Mfg. Co., Pa (ee)
Driver, Wilbur B. Co., NJ
(v,bb,dd,ff)—Ad p 153
Driver-Harris Co., NJ
(bb,dd)
Dudek & Bock Spring Mfg. Co., Ill (ff)
Eastern Rolling Mills, Inc., NY (cc, dd)
Electric Materials Co., Pa (n,o,bb)
Empire Metal Co., NY (n,o)
Erskine Precision Wire Corp., Pa (ff)
Eynon-Dakin Co., Mich (ee)
Federated Metals Div., American Smelting and Refining Co., NY (n, o,q,w,bb,ee)
Fromson Orban Co., Inc., NY (z,cc, dd,ee)
General Cable Corp., NY (ff)
General Plate Div., Metals & Controls Corp., Mass (v)
Glidden Co., Ind (aa)
Glidden Co., Chemicals-Pigments-Metals Div., Md
(aa)—Ad p 391
Gold Leaf & Metallic Powders, Inc., NY (aa)
Grand Rapids Brass Co., Mich (z)
Greenback Industries, Inc., Mich (aa)
H & H Tube & Mfg. Co., Mich (dd,ee)
Hamilton Watch Co., Precision Metals Div., Pa (v,bb,cc,dd,ff)
Hardy, Charles, Inc., NY (aa)
Harris, Benjamin & Co., Ill (w)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hettleman K. & Sons., Inc., Md (w)
Hodgson Foundry Co., Ill (n,o,z)
Hoffman Bronze & Aluminum Casting Co., Ohio (n)
Hommel, O. Co., Pa (aa)
Hoskins Mfg. Co., Mich (bb,dd)
Houston Blow Pipe & Sheet Metal Works, Tex (o,cc)
Hudson, Inc., NJ (w)
Hull, R.O. & Co., Inc., Ohio (n)
Hussey, C.G. & Co., Div. of Copper Range Co., Pa (n,o,z,bb,cc,dd,ee,ff)
Inshield Die & Stamping Co., Ohio (dd)
Inspiration Consolidated Copper Co., NY (n,o,q)
Instrument Specialties Co., Inc., NJ
(dd)—Ad p 381
International Minerals and Metals Corp, NY (w)
International Powder Metallurgy Co., Inc., Pa (z,aa,ee)
Jelliff, C.O. Mfg. Corp., Conn (ff)
Jordan-Rogers Co., Calif (ff)
K. & L. Plating Co., Pa (z)
Kelsey-Hayes Co., Utica Metals Div., NY (o,q,v,w,z,bb,cc,dd,ff)
Kenmore Machine Products, Inc., NY (ee)
Kinkead Industries, Inc., Ill (cc,dd)
Lakeland Industries, Minn (z)
Laminated Shim Co., Conn (cc)
Langsenkamp, F.H. Co., Ind (o,z,bb, cc,dd,ee,ff)
Lavin, R. & Sons, Inc., Ill (n,w)
Leach & Garner Co., Industrial Div., Mass (v,bb,cc,dd,ee,ff)
Lewin-Mathes Div., Cerro De Pasco Corp., Mo (q,w,bb,ee)
Loewenthal Metals Corp., Ill (w)
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Mackenzie Walton Corp., RI (ee)
Magna Mfg. Co., Inc., NJ (aa)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee,ff)
Mallory, P.R. & Co., Inc., Ind (o, bb,dd,ff)
Malone Bronze Powder Works, Inc., NY (aa)
Malone Metal Powders, Inc., NJ (aa)
McGean Chemical Co., Ohio (n,aa,dd)
McGregor-Michigan Corp., Mich (ee)
Metal & Thermit Corp., NJ (n)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ
(aa)—Ad p 415
Miller Co., Conn (dd)
Modern Plating Corp., Ill (n,o,dd,ff)
Mueller Brass Co., Mich
(bb)—Ad p 397
Murray, A.B. Co., Inc., NJ (ee)
National Electric Products Corp., Pa (ff)
National Lead Co., NY (ee)
Nesor Alloy Products Co., NJ (dd,ff)
New England Brass Co., Mass (cc,dd)
New England Electrical Works, Inc., NH (ff)
New England Smelting Works, Inc., Mass (w)
New Jersey Zinc Co., NY
(aa)—Ad pp 386-387
New Haven Copper Co., Conn (n,z,cc, dd)
New Jersey Metals Co., NJ (n,w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Nippert Electric Products Co., Ohio (bb,dd)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb)
Norwalk Powdered Metals, Inc., Conn (aa)
Okonite Co., Sub. of Kennecott Copper Corp., NJ (bb,ff)
Olds Alloys Co., Calif (ee)
Olin Mathieson Chemical Corp., Aluminum Div., NY
(cc)
Olin Mathieson Chemical Corp., Metals Div., NY (cc,dd)
Ormond Mfg. Co., Inc., NJ (dd,ff)
Peerless Roll Leaf Co., Inc., NJ (v,dd)
Penn Brass & Copper Co., Pa (ee)
Phelps Dodge Copper Products Corp., Pa (dd)
Phelps Dodge Refining Corp., NY (n,o)
Plume & Atwood Mfg. Co., Conn (bb, cc,dd,ff)
Precision Tube Co., Inc., Pa (ee)
Rathbone Corp., Mass (o,bb)
Republic Metals Co., Inc., NY (n,w)
Revere Copper & Brass, Inc., NY (n, o,v,z,bb,cc,dd,ee)
Revere Copper & Brass, Inc., Foil Div., NY (v)
Reynolds Aluminum Supply Co., Ga (o, bb,cc,dd,ee)
Rigidized Metals Corp., NY
(cc,dd)
River Smelting & Refining Co., Ohio (w)
Riverside-Alloy Metal Div. H.K. Porter Co., Inc., NJ
(bb,dd,ff)—Ad p 171
Roebling's, John A. Sons Corp., NJ (bb,dd,ff)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (n)
Saginaw Bearing Co., Mich (o,q)
Sall, George Metals Co., Inc., Pa (w)
Sandusky Foundry & Machine Co., Ohio
(ee)
Schumann, I. & Co., Ohio (w)
Scovill Mfg. Co., Mill Products Div., Conn
(bb,cc,dd,ee,ff)—Ad pp 165-166
Sel-Rex Corp., NJ
(n,aa)
Seymour Mfg. Co., Conn
(bb,dd,ff)—Ad p 154
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (ee)
Sipi Metals Corp., Ill (w)
Somers Brass Co., Inc., Conn
(v,dd)—Ad p 150
Sonken-Galamba Corp., Mo (w)
Stamford Rolling Mills Co., Inc., Conn (cc)
Standard Metals Corp., Mass (ee,ff)
Star Heel Plate Co., Inc., NJ (ff)
Stevens, Frederic B., Inc., Mich (n)
Sylvania Electric Products, Inc., Parts Div., Pa
(ff)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (ff)
Terre Haute Bronze & Brass Foundry, Ind (bb,cc,dd,ee)
Thinsheet Metals Co., Conn (cc)
Titan Metal Mfg. Co., Pa
(o,bb)—Ad p 388
Triangle Conduit & Cable Co., Inc., NJ (bb,ee,ff)
Udylite Corp., Mich (n,o,bb)
Ullmann, Inc., Wis (o,ee)
U.S. Bronze Powder Works, Inc., NJ (aa)
U.S. Metal Products Co., Pa (w)
United Wire & Supply Corp., RI (ee,ff)
Universal Castings Corp., Ill (w)
Utica Metals Div., Kelsey-Hayes Co., NY (o,q,v,w,z,bb,cc,dd,ff)
Utility Mfg. Co., Mass (o,bb)
Viking Copper Tube Co., Ohio (ee)
Volco Brass & Copper Co., NJ (cc)
Wallace Tube Co., Div. of Wallace Supplies Mfg. Co., Ill (ee)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Waterbury Rolling Mills, Inc., Conn
(cc,dd)—Ad p 143
Wells, A.H. & Co., Inc., Conn (ee)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
(o,q,v,w,z,bb,cc,dd,ee)
Whitaker Metals Corp., Mo (aa)
Whitehead Metal Products Co., Inc., NY (o,z,bb,cc,dd,ee,ff)
Wisconson Centrifugal Foundry, Inc., Wis (ee)
Wright, Albert Screw Machine Products, Calif (bb)

Cordierite

(see Ceramics)

Cork

Armstrong Cork Co., Pa (r)
Conolite Div., Continental Can Co., Del (bb,cc,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (r,aa,cc)
Dutch Brand Div., Johns-Manville Corp., Ill (r,cc)
Enamel Products Co., Ohio (r)
General Gasket, Inc., Conn (r)
Hollingsworth & Vose Co., Mass (r)
National Gasket & Washer Mfg. Co., Inc., NY (r,cc)
Newth Rubber Co., RI (cc)
Peerless Products Industries, Ill (r)
Sheller Mfg. Corp., Mich (r,bb,cc,ee)
Sillcocks Miller Co., NJ (r)
Spring Packing Corp., Ill (r)
Staver Co., Inc., NY (r,cc)
United Cork Cos., NJ (r)

Corrugated Metals

Aetna Steel Co., Fla (g)
Albert Pipe Supply Co., Inc., NY (g)
Aluminum Co. of America, Pa (a)
Armco Steel Corp., Ohio (g)
Atlantic Steel Co., Ga (g)
Bethlehem Steel Co., Pa (g)
Biersach & Niedermeyer Co., Wis (a,b,g)
Cartwright, R. Tube Products Co., Mich (a)
Clendenin Bros., Inc., Md (a)
Colonial Alloys Co., Pa (a)
Conner Mfg. Co., Ky (c)
Edgecomb Steel & Aluminum Corp., NJ (a,g)
Electric Steel Foundry Co., Ore (g)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Guilfoy Cornice Works, Calif (a,c)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (J)
Inland Steel Co., Ill (g)
Johnson Metal Hose, Inc., Conn (b,f,g)
Jones & Laughlin Steel Corp., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kelley Mfg. Co., Tex (a,g)
Levinson Steel Co., Pa (a,g)
New York Iron Roofing & Corrugating Co., Inc., NJ (a,g)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Republic Steel Corp., Ohio
(g)
Revere Copper & Brass, Inc., NY (a,b)
Reynolds Aluminum Supply Co., Ga (a,g)
Reynolds Metals Co., Va (a)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Staver Co., Inc., NY (a,b,c,d,e,f,g,h,J)
Sun Steel Co., Ill (a,g,h)

Cupro-Nickel

(see Copper)

Diallyl Phthalate

(DAP)
Chemicals & Plastics Div., Food Machinery & Chemical Corp., NY (p)
Cordo Chemical Corp., Conn
(x,y)
Cordo Molding Products, Inc., NY
(y)
Durez Plastics Div., Hooker Chemical Corp., NY
(y)—Ad pp 252-253
Dyna-Therm Chemical Corp., Calif
(p)
F M C Organic Chemicals Div., Food Machinery & Chemical Corp., NY (p)
Fiber Glass Industries, Inc., NY (x,y,cc)
Fluoro-Plastics, Inc., Div. of Flexrock Co., Pa (bb,cc)
Formica Corp., Sub. of American Cyanamid Corp., Ohio (bb,cc,dd)
Hays Mfg. Co., Pa (y)
Interchemical Corp., NY (p,x,y)
Maloney, F.H. Co., Tex (y)
Mesa Plastics Co., Calif (p,y,bb,cc)
Synthane Corp., Pa (bb,cc,dd,ee)
U.S. Polymeric Chemicals, Inc., Conn (s)

Die Castings

(see Castings)

Diffusion Coatings

(calorized, chromized, sherardized)
Alloy Surfaces Co., Inc., Del
Calorizing Co., Pa
Chromalloy Corp., NY
Chromizing Co., Calif
Colonial Alloys Co., Pa
General Extrusions, Inc., Ohio
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Modern Plating Corp., Ill
Nylok Corp., NJ
Vanamatic Co., Ohio

Dip Coatings

(see Immersion Coatings; Galvanizers)

Dispersion Coatings

(see Organic Coatings)

Drawn, Pressed Parts

(not incl. stampings)
Abalon Precision Mfg. Corp., NY (a,b,c,g)
Ackermann Mfg. Co., W. Va (g)
Acme Metal Spinning, Inc., Minn (a,b,c,d,e,f,g,h,J)
Acme Stamping & Mfg. Co., Pa (a,b,g)
Acorn Sheet Metal Mfg. Co., Inc., Ill (a,g)
Alco Products, Inc., NY (g)
Alloy Products Corp., Wis
(a,f,g,h)—Ad p 408
Aluminum Co. of America, Pa (a)
Aluminum Goods Mfg., Wis (a,g)
Aluminum Specialty Co., Wis (a,g)
American Brass Co., Sub. of Anaconda Co., NY
(b)—Ad p 377
American Car & Foundry Div., ACF Industries, Inc., NY (a,e,g)
American Forge & Mfg. Co., Pa (g)
American Machine & Foundry Co., Cleveland Welding Div., Ohio (f,g,h)
American Silver Co., Inc., NY (a,b,e,f,g)
Anchor Metal Spinning Co., Ohio (a,b,c,d,f,g)
Anthes Force Oiler Co., Iowa (a,g)
Armco Steel Corp., Sheffield Div., Mo (g)
Arrow Metal Products Corp., NJ (a)
Arvin Industries, Inc., Ind (a,g)
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Atlas Metal Parts Co., Wis (a,b,c,g)
Auld, D.L. Co., Ohio (c)
Belmont Smelting & Refining Works, NY
(a,b,g)
Bethlehem Steel Co., Pa (g)
Boots Aircraft Nut Corp., Conn (g)
Brandt, Charles T., Inc., Md (a,b,e,g)
Brooks & Perkins, Inc., Mich
(a,e,g,h)—Ad p 410
Carpenter Steel Co., Pa (g)
Cly-Del Mfg. Co., Conn (a,b,f,g,J)
Colonial Alloys Co., Pa (a)
Columbus Bolt & Forging Co., Ohio (a,b,g)
Commercial Shearing & Stamping Co., Ohio (a,f,g)
Consolidated Fruit Jar Co., NJ (a,b,c,d,g,J)
Cooley, W.J. & Co., Tenn (a,b,c,g)
Crosby Co., NY (a,b,g)
Crown Metal Co., Wis (d)
Crucible Steel Co. of America, Pa
(g,h)
Cuyahoga Stamping Co., Ohio (a,b,g)
Cyril Bath Co., Ohio (a,e,f,g,h)
Dahlin, C.A. Co., Ill (a,b,f,g,J)
Dana Corp., Auburn Div., Ind (g)
Dayton Rogers Mfg. Co., Minn (a,b,c,g,J)
Detroit Stamping Co., Mich
(a,b,g)
Dirilyte Co. of America, Inc., Ind (a,b)
Division Lead Co., Ill (d)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Eastern Tool & Mfg. Co., NJ (a,b,c,d,g,h)
Eastern Tool & Stamping Co., Inc., Mass (a,b,c)
Eaton Mfg. Co., Reliance Div., Ohio (g)
Edgecomb Steel & Aluminum Corp., NJ (g)
Electric Auto-Lite Co., Ohio (c)
Electric Materials Co., Pa (b)
Electric Steel Foundry Co., Ore (g)
Etched Products Corp., NY (a,b,g)
Evans, George Corp., Ill (a)
Falstrom Co., NJ (a,b,e,f,h)
Farwell Metal Fabricating, Minn (a,b,e,f,g)
Fletcher Enamel Co., W. Va (a,b,c,d,e,f,g)
Forg, Peter Mfg. Co., Mass (a,b,c,h)
Frasse, Peter A. & Co., Inc., NY
(a,g)
Garco Mfg. Co., Inc., Ill (a,b,c,e,f,g,h,J)
General Alloys Co., Mass (a,b,c,f,g)
General Findings & Supply Co., Industrial Div., Mass (b,f,g)
General Plate Div., Metals & Controls Corp., Mass (a,b,c,e,f,g,h,J)
Geuder, Paeschke & Frey Co., Wis (a,c,f,g)
Grammes, L.F. & Sons, Inc., Pa (a,b,c,g)
H & H Tube & Mfg. Co., Mich (b)
Hydroforming Co. of America, Ill (a,b,f,g,h)
Ideal Can Co., Mass (a,b,g)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (J)
Ingersoll Products Div., Borg-Warner Corp., Ill (g)
Inland Steel Co., Ill (g)
International Silver Co., Eyelet Specialty Div., Conn (a,b,g)
Irwin-Sensenich Corp., Pa (g)
Jones & Laughlin Steel Corp., Pa (g)
Kees, F.D. Mfg. Co., Neb (a,g)
Kelley Mfg. Co., Tex (a,g)
Kelsey-Hayes Co., Mich (g)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,J)
Koehler Mfg. Co., Mass (a,b,c,g)
Lakewood Metal Products, Inc., Conn
Lansing Stamping Co., Mich (g)
Latrobe Steel Co., Pa
(g)
Leake Engineering Co., Mich (a,b,c,d,e,f,g,h,J)
Leake Stamping Div., Monarch Products Co., Mich (a,b,f,g,h)
Lenape Hydraulic Pressing & Forging Co., Pa
(a,b,g)—Ad p 396
Linde Co., Div. of Union Carbide Corp., NY (g)
Lukens Steel Co., Pa
(a,b,e,f,g,h)
Lundquist Tool & Mfg. Co., Inc., Mass (a,g)
Magline, Inc., Mich (a,e)
Magnesium Co. of America, Ind (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Mahon, R.C. Co., Mich (a,g)
Manganese Steel Forge Co., Pa (g)
Manufacturers Service, Inc., Ohio (a,b,g)
Matthiessen & Hegeler Zinc Co., Ill (J)
Midwest Stamping & Mfg. Co., Ohio (a,b,f,g)
Milwaukee Stamping Co., Wis (a,b,g)
Mirro Aluminum Co., Wis (a)
Morse, Fred W. Co., RI (a,b,c,g,J)
National Metal Products Co., Pa (a,b,d,g,J)
National Moldite Co., NJ (c)
Nichols, L.O. & Son Mfg. Co., Mo (a,b,c,g)
Nichols Wire & Aluminum Co., Iowa (a)
Nippert Electric Products Co., Ohio (b)
Olean Electro Plating Co., NY (a,b,g)
Olderman Mfg. Corp., Conn (b)
Olin Mathieson Chemical Corp., Metals Div., NY (b)
Parish Pressed Steel Div., Dana Corp., Pa (a,g)
Peterson Products Corp., Ill (a,b,f,g)
Phoenix Products Co., Wis (a,b,c,f,g)
Pioneer Stamped Products Co., NY (a,b,e,f,g)
Pittsburgh Steel Co., Pa (b,c,f,g,J)
Plume & Atwood Mfg. Co., Conn (a,b,c,f,g,l)
Polar Ware Co., Wis (a,b,f,g)
Powell Pressed Steel Co., Ohio (a,g)
Precision Extrusions, Inc., Ill (a)
Pressed Steel Co., Pa (a,b,f,g)
Pressed Steel Tank Co., Wis (a,b,c,e,f,g,h)
Queen Products Co., Inc., Ky (a,g)
Regal Ware, Inc., Wis (a,b,g)
Republic Steel Corp., Ohio
(g)
Revere Copper & Brass, Inc., NY (a,b,c,f,g,J)
Reynolds Metals Co., Va (a)
Rockwell - Standard Corp., Bossert Stamping Div., NY
(a,b,c,d,f,g,h,J)
Rolock, Inc., Conn (f)
Scaife Co., Pa (a,b,c,e,f,g,h)
Scovill Mfg. Co., Mill Products Div., Conn
(a,b,c,f,g)
Shank Metal Products Co., NY
Simonsen Metal Products Co., Ill (a,g)
Smoot-Holman Co., Calif (g)
Southern Metal Products Co., La (a,g)
Southwestern Porcelain Steel Corp., Okla (g)
Spincraft, Inc., Wis (a,b,g)
Star Stamping Co., Mich (a,b,g)
Staver Co., Inc., NY (a,b,c,d,e,f,g,h,J)
Stirrup Metal Products Corp., NJ (a,b,c,g)

Superior Spinning & Stamping Co., Ohio (a,b,f,g)
Sylvania Electric Products, Inc., Parts Div., Pa (a,b,c,f,g)
Teiner, Roland Co., Inc., Mass (a,b,c,f,g,h)
Textile Shield Co., Inc., Mass (a,b,g)
Thompson-Bremer & Co., Ill (a,b,c,f,g,h)
Titan Metal Mfg. Co., Pa (b)
Titanium Metals Corp. of America, NY (h)
Triangle Stamping Co., Ohio (a,b,c,d,f,g,j)
United-Carr Fastener Corp., Mass (a,b,g)
Van Huffel Tube Corp., Ohio (a,b,g)
Volkert Stampings, Inc., NY (b,f,g)
Vollrath Co., Wis (g)
Vulcan-Kidd Steel Div., H.K. Porte Co. Inc., Pa (g)
Waterbury Cos., Inc., Conn (a,b,g)
Waterbury Pressed Metal Co., Conn (a,b,f,g)
Waterman Industries, Inc., Calif (a,b,g)
Wayne Foundry & Stamping Co., Mich (a,b,e,g,h)
Wesbar Stamping Corp., Wis (a,b,c,g)
Whitehead Metal Products Co., Inc., NY (a,b,f,g)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (a,b,c,e,f,g)
Wisconsin Tool & Stamping Co., Ill (a,b,g)
Wolverine Tube Div., Calumet & Hecla, Inc., Mich (a)
Worcester Pressed Steel Co., Mass (a,b,c,e,f,g,h,j)
Worcester Stamped Metal Co., Mass (a,b,f,g,h,j)
Wuest Bros., Inc., Ky (a,b,c,f,g)
Wycoff Steel Co., Pa (g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Mfg., Inc., Ohio (a,g)

Drop Forgings

(see Forgings)

Ductile Iron

(see Iron)

Electrodes, Welding

(see Filler Metals)

Electroless Coatings

(see Immersion Coatings)

Electroplated Coatings

(Electroplaters; see also Preplated Metals)

A & A Die Casting Co., Calif
Abalon Precision Mfg. Corp., NY
Accurate Anodizing Corp., Ill
Acme Plating Co., Ohio
Ainsworth Precision Castings Co., Div. of Harsco Corp., Mich
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Allied Research Products, Inc., Md
Aluminum Billets, Inc., Ohio
American Emblem Co., Inc., NY
American Nickeloid Co., Ill
American Platinum & Silver Div., Engelhard Industries, Inc., NY
—Ad p 35
American Smelting & Refining Co., NY
Apollo Metal Works, Ill
Atlantic Brass Works, Inc., Ill
Atlantic Steel Co., Ga
Auld, D.L. Co., Ohio
Bart Mfg. Corp., NJ
Bishop, J. & Co. Platinum Works, Pa.
Brewer-Titchener Corp., NY
Brooks & Perkins, Inc., Mich
—Ad p 410
Chromium Corp. of America, NY
Cincinnati Pump & Mfg. Co., Inc., Ohio
City Plating Works, Inc., Conn
Cohan Epner Co., Inc., NY
Colonial Alloys Co., Pa
Columbus Dental Mfg. Co., Ohio
Commercial Screw Products Co., Ohio
Conforming Matrix Corp., Ohio
Continental Die Casting Corp., Mich
Croname, Inc., Ill
Designers Metal Corp., Ill
Diamond Alkali Co., Ohio
Diversey Corp., Metal Industries Div., Ill
Doehler-Jarvis Div., National Lead Co., Ohio
Dollin Corp., NJ
Du-Wel Metal Products, Inc., Mich
Eaton Mfg. Co., Reliance Div., Ohio
Edna Lite Optical Co., Inc., NY
Electric Auto-Lite Co., Ohio
Electric Materials Co., Pa
Electrolizing Corp., Ohio
Fox Co., Ohio
General Findings & Supply Co., Industrial Div., Mass
Grand Rapids Brass Co., Mich
Hardy Mfg. Corp., Ind
Harshaw Chemical Co., Ohio
Hilfinger Corp., Ohio
Hull, R.O. & Co., Inc., Ohio
Indium Corp. of America, NY
Industrial Chromium Corp., Mass
K. & L. Plating Co., Pa
Kees, F.D. Mfg. Co., Neb
La France Precision Casting Co., Pa
Lakeland Industries, Minn
Lea Mfg. Co., Conn
Litho-Strip Corp., M.M. Young Div., Ill
Lundquist Tool & Mfg Co., Inc., Mass
MacDermid, Inc., Conn
Marlane Development Co., Inc., NY
Master Chrome Service, Inc., Ohio
McGean Chemical Co., Ohio
Mechanical Plating Co., Ill
Medico Industries, Inc., Pa
Merrimac Brass, Mass
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metals & Controls Corp., Mass
Metaplast Process, Inc., NY
Michigan Chrome & Chemical Co., Mich
Modern Plating Corp., Ill
National Malleable & Steel Castings Co., Ohio
New Jersey Metals Co., NJ
New Jersey Zinc Co., NY
Norgren-Stemac, Inc., Colo
Nylok Corp., NJ
Olean Electro Plating Co., NY
Ormond Mfg. Co., Inc., NJ
Penn Metal Co., Inc., W. Va
Plume & Atwood Mfg. Co., Conn
Promat Div., Poor & Co., Ill
Reed & Prince Mfg. Co., Mass
Republic Steel Corp., Ohio
Reynolds Wire Div., National-Standard Co., Ill
Rustproofing & Metal Finishing Corp., Mass
St Eloi Corp., Ohio
St. Louis Diecasting Corp., Mo
Seal-Peel, Inc., Mich
Sifco Metachemical, Inc., Ohio
Sommer Metalcraft Corp., Ind
Southern Metal Products Co., La
Spencer Nahm Co., Calif
Steel Protection & Chemical Co., Ind
Stevens, Frederic B., Inc., Mich
Stirrup Metal Products Corp., NJ
Sylvania Electric Products, Inc., Parts Div., Pa
Thermo Materials, Inc., Calif
Tiarco Corp., NJ
Tubular Rivet & Stud Co., Mass
Udylite Corp., Mich
United-Carr Fastener Corp., Mass
Vanamatic Co., Ohio
Van der Horst Corp., NY
Van Valkenburg, L.D. Co., Mass
WLS Stamping Co., Ohio
Wayne Foundry & Stamping Co., Mich
Wesbar Stamping Corp., Wis
Western Coating Co., Mich
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY
Williams Gold Refining Co., Inc., NY
Woodstock Div., Electric Auto-Lite Co., Ill
Worcester Wire Works Div., National-Standard Co., Mass
Worth Co., Wis
Wyandote Chemicals Corp., Mich
Zeller Corp., Ohio

Embossed Metals

(incl. rigidized)

Aluminum Co. of America, Pa (a)
American Nickeloid Co., Ind. (a,b,g,j)
Ardmore Products, Inc., NJ (a,b,c,d,e,f,g,h,j)
Atlantic Steel Co., Ga (a,b,g)
Auld, D.L. Co., Ohio (a,b)
Biersach & Niedermeyer Co., Wis (a,b,g)
Clad-Rex Corp., Ill
Colonial Alloys Co., Pa (a)
Cooley, W.J. & Co., Tenn (a,b,c,g)
Copper & Brass Sales, Inc., Mich (a)
Croname Inc., Ill (a,b,f,g,j)
Electric Steel Foundry Co., Ore (a,b,c,g)
Fairmont Aluminum Co., Va (a)
Falstrom Co., NJ (a,b,e,f,g,h)
Grammes, L.F. & Sons, Inc., Pa (a,b,g)
Grigoleit Co., Ill (a,g)
Hawkridge Bros. Co., Mass (a)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Langsenkamp, F.H. Co., Ind (a)
Mahon, R.C. Co., Mich (a)
McKinney Mfg. Co., Pa (a,b,e,f,g)
Mechanical Steel Tubing Corp., NY (a,g)
Metal Goods Corp., Mo (a)
Morse, Fred W. Co., RI (a,b,c,g)
Olin Mathieson Chemical Corp., Aluminum Div., NY (a)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Premier Metal Works, Inc., Ill (a,b,f,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a)
Reynolds Aluminum Supply Co., Ga (a)
Reynolds Metal Co., Ky (a)
Rigidized Metals Corp., NY (a,b,f,g,h)—Ad p 420
Ryerson, Joseph T. & Son, Inc., Ill (a)
Sharon Steel Corp., Pa (g)
Southern Aluminum Finishing Co., Inc., Ga (a)
Southwestern Porcelain Steel Corp., Okla (g)
Sun Steel Co., Ill (a,g,h)
Wesbar Stamping Corp., Wis (a,b,c,g)
Whitehead Metal Products Co., Inc., NY (a,b,f,g)
Wilson-Hurd Mfg. Co., Inc., Wis (a)

Emulsion Coatings

(see Organic Coatings)

Enamels

(see Organic Coatings)

Epoxies

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p)
Amercoat Corp., Calif (ee)
American Metaseal Corp., NJ (x,ee)
Angier Adhesives Div., Interchemical Corp., Mass (x)
Aries Laboratories, Inc., NY (p,x,y)
Armstrong Products Co., Ind (x)
Atlas Mineral Products Co., Pa (x)
Bakelite Co., Div. of Union Carbide Corp., NY (p,x)
Biggs, Carl H. Co., Inc., Calif (t,x,y)
Bisonite Co., Inc., NY (x)
Borden Chemical Div., Borden Co., NY (p)
Cadillac Plastic & Chemical Co., Mich (p,x,y)
Chemical Coatings & Engineering Co., Inc., Pa (p,x)
Chemical Development Corp., Mass (p,x)

K E Y

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Ciba Co., Inc., Plastics Div., Pa
(p,x)—Ad pp 228-229
Colonial Kolonite Co., Ill (bb,cc)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn
(x,y)
Cordo Molding Products, Inc., NY
(y)
Curbell, Inc., NY (bb,cc,ee)
Dayton Rubber Co., Ohio (x,y)
Dennis Chemical Co., Mo (y)
Devcon Corp., Mass (x,y)
Dow Chemical Co., Plastics Div., Mich
(p)
Dyna-Therm Chemical Corp., Calif
(p)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Electrofilm, Inc., Calif (t)
Emerson & Cuming, Inc., Mass (p,u, x,bb)
Fiber Glass Industries, Inc., NY (x,y, cc)
Fibercast Div., Youngstown Sheet & Tube Co., Okla (ee)
Formica Corp., Sub. of American Cyanamid Co., Ohio (cc,ee)
Foss Mfg. Co., Plastics Div., Id (x)
Fry Plastics Co., Calif (p,x)
Fuller, H.B. Co., Minn (x)
Furane Plastics, Inc., Calif (x,y)
Galigher Co., Utah (p,s,x)
General Electric Co., Laminated Products Dept., Ohio
(bb,cc,ee)
General Plastics Mfg. Co., Wash (x)
Glass Reinforced Plastics Corp., Ohio (bb,ee)
Glo-Brite Products, Inc., Ill (u)
Hardman, H.V. Co., Inc., NJ (x,bb)
Heil Process Equipment Corp., Ohio (x)
Houghton Laboratories, Inc., NY
(p,x,y,bb,cc,dd,ee)—Ad p 248
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc., Ky (p,x)
Kish Industries, Inc., Mich (x)
Kurz, Kasch, Inc., Ohio (y)
Maloney, F.H. Co., Tex (x,y)
Marblette Corp., NY (x,y,bb)
Mesa Plastics Co., Calif (p,y,bb,cc)
Mica Corp., Calif (cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (cc)
Micarta Div., Westinghouse Electric Corp., SC (x,y)
Minneapolis Honeywell Regulator Co., Minn (p,u,x)
Narmco Resins & Coatings Co., Calif (u,x,y,dd)
National Polymer Products Inc., Sub. of Polymer Corp., Pa
(y)
National Vulcanized Fibre Co., Del (cc)
New England Laminates Co., Inc., Conn
(cc)
Norrich Plastics Corp., NY (bb,cc,dd, ee)
Northern Plastics Corp., Wis (cc,dd)
Ohio Adhesives Corp., Ohio (x)
Panelyte Div., St. Regis Paper Co., NY (x,bb,cc,dd,ee)
Permacel, Inc., NJ (p,x,y)
Philrus Products Co., NJ (bb,cc,dd,ee)
Poly Resins, Calif (p,x)
Polygon Plastic Co., Ind (ee)
Porter, William Co., Calif (cc,ee)
Pyrosil, Inc., Ohio (x,cc)
Quelcor, Inc., Pa (t)
Raybestos - Manhattan, Inc., Plastic Products Div., Conn
(x,cc)
Raybestos-Manhattan, Inc., Raybestos Div., Conn (x)
Reichhold Chemicals, Inc., NY (p,x)
Ren Plastics, Inc., Mich (p,s,x,y,ee)
Reynolds Chemical Products Co., Mich
(p,x)
Rezolin, Inc., Calif (p,x)
Richardson Co., NY (bb,cc,ee)
Rogers Corp., Conn (y)
Roller Reinforced Plastics, Ohio (x)
Schwartz Chemical Co., Inc., NY (x)
Shell Chemical Corp., NY (p)
Spaulding Fibre Co., Inc., NY
(bb,cc,dd,ee)
Specialty Resins Co., Calif (x,y)
Strick Plastics Co., Pa (u,cc)
Sun Chemical Corp., Electro Technical Div., NJ (x)
Swedlow, Inc., Calif (cc)
Synthane Corp., Pa (bb,cc,dd,ee)
Taylor Fibre Co., Pa
(bb,cc,dd,ee)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY (p,x)
U.S. Gypsum Co., Ill (x)
U.S. Polymeric Chemicals, Inc., Conn (s)

Ethyl Cellulose

Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
American Hard Rubber Co. Div. of Amerace Corp., NJ
(bb,dd,ee)
American Molding Powder & Chemical Co., NY (y)
American Products Mfg. Co., Inc., La (t)
Anchor Plastics Co., Inc., NY (bb,dd, ee)
Auburn Plastics, Inc., NY (bb,dd,ee)
Bamberger, Claude P., Inc., NJ (y)
Bischoff Chemical Corp., NY (u)
Campco Div., Chicago Molded Products Corp., Ill (t,cc)
Carroll, J.B. Co., Ill (cc)
Coating Products, Inc., NJ (t,cc)
Continental-Diamond Fibre Corp., Del (ee)
CrystalX Corp., Pa (bb,cc,dd,ee)
Davis, Joseph Plastics Co., NJ (t,y, bb,cc,dd,ee)
Denver Plastics, Inc., Colo (u)
Dow Chemical Co., Plastics Div., Mich
(p,y,cc)—Ad p 239
Dyna-Therma Chemical Corp., Calif
(p)
Falge Engineering Corp., Md (t)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Gering Products, Inc., NJ (y,bb,dd)
Glass Laboratories, NY (bb,dd)
H & R Industries, Pa (bb,cc,dd,ee)
Hercules Powder Co., Inc., Del
(p)
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
K S H Plastics, Inc., Mo (bb,cc,dd)
Lus-Trus Corp., Mich cc)
Muehlstein, H. & Co., Inc., NY (y)
Nixon Nitration Works, NJ (bb,cc)
Omni Products Corp., NY (y,bb,cc)
Panelyte Div., St. Regis Paper Co., NY (cc)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Pyramid Plastics, Inc., Ill (bb,dd,ee)
Schwab Plastic Corp., Mich (bb,cc,dd, ee)
Simon Products Co., Ill (t)
Southern Plastics Co., SC (bb,cc,dd,ee)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,ee)
Western Felt Works, Ill
(cc)
World Plastics, NY (bb,cc,dd,ee)

Expanded Metals

Aluminum Co. of America, Pa
(a)
Aluminum Specialty Co., Wis (a)
American Metal Products, Inc., Ohio (g)
Atlantic Steel Co., Ga (g)
Biersach & Niedermeyer Co., Wis (a, b,c,f,g)
Castle, A.M. & Co., Ill (a,g)
Clad-Rex Corp., Ill
(a,g)
Colonial Alloys Co., Pa (a)
Designers Metal Corp., Ill (a,b,d,e,f, g,j)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Ellwood City Iron & Wire Co., Pa (c)
Evans, George Corp., Ill (a)
Flexonics Corp., Ill (g)
Hawkridge Bros. Co., Mass (a)
Hazledine, E.T. Co., Ind (g)
Houston Blow Pipe & Sheet Metal Works, Tex (g)
Ideal Can Co., Mass (g)
Kees, F.D. Mfg. Co., Neb (g)
Levinson Steel Co., Pa (a,g)
Mechanical Steel Tubing Corp., NY (a,g)
Metal Goods Corp., Mo (g)
Penn Metal Co., Inc., Mass (a,b,c,d, f,g,h,j)
Republic Steel Corp., Ohio
(g)
Reynolds Aluminum Supply Co., Ga (a, g)
Rolled Alloys, Inc., Mich (f)
Rolock Inc., Conn (f)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Standard Metals Corp., Mass (f)
Trojan Steel Co., W. Va (g)
U.S. Gypsum Co., Ill (a,g)
Vulcan Rail & Construction Co., NY (g)
Ward, H.H. Co., Pa (g)
Wheeling Corrugating Co., W.Va
Whitehead Metal Products Co., Inc., NY (a,f)
Whyte, Oliver Co., Inc., NY (a,g)
Wire & Iron Products, Inc., Mich (f,g)

Extrusions

(see below; also Impact Extrusions; Tubing)

Extrusions, Metallic

(excl. Tubing, Pipe)

Accurate Metal Weather Strip Co., Inc., NY (a,b)
Adams Engineering Co., Inc., Fla (a)
Aerolite Extrusion Co., Ohio (a)
Allegheny Ludlum Steel Corp., Pa
(g)
Aluminum Co. of America, Pa (a,e)
Aluminum Billets, Inc., Ohio (a)
Aluminum Extrusions, Inc., Mich (a)
American Brass Co., Sub. of Anaconda Co., NY
(b)
American Machine & Foundry Co., Ohio (g,h)
American Reed Co., Inc., Mass (e)
Ampco Metal, Inc., Wis (b)
Anaconda Aluminum Co., Sub. of Anaconda Co., Ky (a)
Armco Steel Corp., Sheffield Div., Mo (g)
Arvin Industries, Inc., Ind (a)
Atlantic India Rubber Works, Inc., Ill (m)
Atlantic Steel Co., Ga (a)
Auld, D.L. Co., Ohio (a)
B & T Metals Co., Ohio (a)
Babcock & Wilcox Co., Tubular Products Div., Pa
(c,g)—Ad p 383
Badger Aluminum Extrusions, NY (a)
Beck, I. & Sons, Inc., NY (a,b)
Belmont Aluminum Extrusion Co., Pa (a)
Benada Aluminum Products Co., Ohio (a)
Beryllium Corp., Pa
(b)
Bohn Aluminum & Brass Corp., Mich (a,b)
Bonnell, William L. Co., Inc., Ga (a)
Bridgeport Brass Co., Conn
(a,b,h)—Ad p 152
Brinkerhoff Brass & Bronze Works, Inc., NY (a,b)
Bristol Brass Corp., Conn (b)
Bunker Hill Co., Calif (d)
Burgess-Norton Mfg. Co., Ill (c)
Cameron Iron Works, Inc., Special Products Div., Tex
(c,f,g,h)
Capitol Products Corp., Pa (a)
Castle, A.M. & Co., Ill (a)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (b)
Clendenin Bros., Inc., Md (a,b)
Colonial Alloys Co., Pa (a)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (g)
Columbus Bolt & Forging Co., Ohio (a,b,g)
Consolidated Fruit Jar Co., NJ (d)
Copper & Brass Sales, Inc., Mich (a, b,e)
Corson Industries, Pa (a)
Craft Mfg. Co., Ill (a,b,c,e,f,g,h,j)
Crown Metal Co., Wis (d)
Curtiss-Wright Corp., Metals Processing Div., NY (f,g,h)
Cyril Bath Co., Ohio (a,h)
Detroit Gasket & Mfg. Co., Extruded Metals Div., Mich (a)
Division Lead Co., Ill (d)
Dixie Aluminum Corp., Ga (a)
Dixie Bronze Co., Ala (b)
Doehler-Jarvis Div., National Lead Co., Ohio (a)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Dresser Mfg. Div., Dresser Industries, Inc., Pa (f,g)
Empire Metal Co., NY (d)
Etched Products Corp., NY (a)
Eureka Electric Products Co., Pa (b)
Fletcher Enamel Co., W. Va (a,b,c,d, e,f)
Flynn, Michael Mfg. Co., Pa (a)
Frasse, Peter A. & Co., Inc., NY
(g)
Fromson Orban Co., Inc., NY (a)
Fuller, W.P. & Co., Calif (j)
Garlock Packing Co., NY (k,m)
General Extrusions, Inc., Ohio
(a)—Ad p 416
Grigoleit Co., Ill (a,g)
Harvey Aluminum Sales, Inc., Calif (a,g,h)
Hawkridge Bros. Co., Mass (a)
Himmel Bros. Co., Conn (a)
Hokin Aluminum Co., Ill (a)
Hunter Douglas Aluminum Div., Bridgeport Brass Co., Calif (a,b)
International Nickel Co., Inc., NY (f)
Jarl Extrusions, Inc., NY
(a)—Ad p 412
Jasco Aluminum Products Co., NY (a)
Jet Specialties Co., Inc., Calif (k)
Johnson Bronze, Pa (a,b)
Jones & Laughlin Steel Corp., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kawneer Co., Mich (a)
Kelsey-Hayes Co., Mich (g)
Kroh Wagner, Ill (a)
Langsenkamp, F.H. Co., Ind (a)
Light Metals Corp., Mich (a)

Magnode Products, Inc., Ohio (a,e)
Metal Goods Corp., Mo (a)
Metal Trims, Inc., Miss (a)
Moczik Tool & Die Works, Mich (a,b)
Monarch Tool & Mfg. Co., Ky (a)
Mueller Brass Co., Mich (a,b)—Ad p 397
National Aluminum Co., Ohio (a)
National Lead Co., NY (a,b,d)
National Metal Products Co., Pa (a,b)
National Tube Div., U.S. Steel Corp., Pa (g)
New Jersey Aluminum Extrusion Co., Inc., NJ (a)
Nuclear Metals, Inc., Mass (a,b,c,e,f,g,h)
Olin Mathieson Chemical Corp., Aluminum Div., NY (a)
Olin Mathieson Chemical Corp., Metals Div., NY (a)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Penn Brass & Copper Co., Pa (a)
Penn Extrusion Corp., Pa (a)
Pfister Aluminum Corp., NJ (a)
Phelps Dodge Copper Products Corp., Pa
Pioneer Aluminum, Inc., Calif (a)
Pittsburgh Plate Glass Co., Pa (a,g)
Precision Extrusions, Inc., Ill (a)
Raybestos-Manhattan, Inc., NJ (k,m)
Republic Metals Co., Inc., NY (d)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a,b)
Reynolds Aluminum Supply Co., Ga (a)
Reynolds Metals Co., Va (a)
Rockwell - Standard Corp., Bossert Stamping Div., NY (g)
Royce Aluminum Corp., Mass (a)
Ryerson, Joseph T. & Son, Inc., Ill (a)
Saramar Aluminum Co., Ohio (a)
Scaife Co., Pa (b,c,f,g)
Scovill Mfg. Co., Conn (b)
Serrick Corp., John Lees Div., Ind (a,g)
Southern Aluminum Finishing Co. Inc., Ga (a)
Southern Extrusions, Inc., Ark (a)
Stainless Metals, Inc., NY (g)
Steel Industries, Inc., Ind (b,g)
Superior Industries, Inc., Ohio (a)
Supplex Co., Div. of Amerace Corp., NJ (k)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Texas Aluminum Co., Inc., Tex (a)
Textron Metals Co., Ohio (a)
Thompson Products, Inc., Light Metals Div., Ohio (a)
Thompson Products, Inc., Valve Div., Ohio (f,g)
Titan Metal Mfg. Co., Pa (b)—Ad p 388
Titanium Metals Corp. of America, NY (h)
Toledo Stamping & Mfg. Co., Ohio (a,g)
Trim Alloys, Inc., Mass (a)
Union Steel Corp., NJ (g)
United Shoe Machinery Corp., Mass (f,g)
U.S. Extrusions Corp., NY (a)
U.S. Steel Corp., Pa (g)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
Universal Converting Corp., Mass (a)
Uniworld Research Corp. of America, Ohio (c)
Vulcan Metal Products, Inc., Ala (a)
Vulcan Rail & Construction Co., NY (a)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (g)
W.F. Mfg. Co., Calif (a)
Warner Mfg. Corp., NJ (a)
Werner, R.D. Co., Inc., NY (a)
Wesbar Stamping Corp., Wis (a,b,c,g)
White Metal Rolling & Stamping Corp., NY (a,e)—Ad p 418
Whitehead Metal Products Co., Inc., NY (a)
Wolverine Tube Div., Calumet & Hecla, Inc., Mich (a)
Worcester Pressed Steel Co., Mass (a, g)
Youngstown Kitchens Div., American Standard Co., Ohio (g)
Youngstown Mfg., Inc., Ohio (a)

Extrusions, Nonmetallic

(excl. Tubing, Pipe)

Ace Plastic Co., NY (k)
Allegheny Plastics, Inc., Pa (k)
Allied Resinous Products, Inc., Ohio (k)
Amco Plastic Pipe Co., Calif (k)
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l,m)
American Molding Co., Calif (k)
American Plastics Corp., NY (k)
Anchor Plastics Co., Inc., NY (k)
Anesite Co., Ill (l)
Atlas Mineral Products Co., Pa (k)
Auburn Mfg. Co., Conn (k,m)—Ad p 420
Auburn Plastics, Inc., NY (k,m)
Automotive Rubber Co., Inc., Mich (m)
Beck, I. & Sons, Inc., NY (m)
Bond International, Inc., Mich (m)
Borden Co., Borden Chemical Div., NY (k)
Borden Chemical Co., Resinite Dept., Calif (k)
Bowling Green Rubber Co., Ohio (m)
Brown Rubber Co., Inc., Ind (m)
Button Corp. of America, NJ (k)
Byers, A.M. Co., Pa (k)
Cadillac Plastic & Chemical Co., Mich (k,l)
Cambridge-Panelyte Molded Plastics Co., Div. of St. Regis Paper Co., Ohio (k)
Campco Div., Chicago Molded Products Corp., Ill (k)
Canfield, H.O. Co., Va
Carlon Products Corp., Ohio (k)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (k)
Celluplastic Corp., NJ (k)
Chardon Rubber Co., Ohio (k)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works Co., Ohio (k)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (k,m)
Connecticut Hard Rubber Co., Conn (m)
Continental Rubber Works, Pa (m)
Contour Extrusion Co., NY (k)
Crescent Plastics, Inc., Ind (k)
Davis, Joseph Plastics Co., NJ (k)
Detroit Macold Corp., Mich (k,m)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Eberhard Faber Pencil Co., NY (m)
Eclipse Plastic Industries, Inc., Fla (k)
Electric Auto-Lite Co., Ohio (k)
Eljay Corp., Md (l)
Enflo Corp., NJ (l)
Extruders, Inc., Calif (k)
Faultless Rubber Co., Ohio (m)
Frost Rubber Co., Ill (m)
Fry Plastics Co., Calif (k)
Galigher Co., Utah (k)
Garlock Packing Co., NY (k,m)
Geauga Industries Co., Ohio (k,m)
General American Transportation Corp., Ill (k)
General American Transportation Corp., Plastics Div., Ill (k)—Ad p 425
General Electric Co., Chemical & Metallurgical Div., Ill (k)
General Gasket, Inc., Conn (m)
General Plastics Corp., Ind (k)
Gering Products, Inc., NJ (k)
Gilman Bros. Co., Conn (k)
Glass Laboratories, Inc., NY (k)
Glass Reinforced Plastics Corp., Ohio (l)
Glastic Corp., Ohio (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Gossett and Hill Co., Ill (k)
Gotham Plastics Corp., NY (k,r)
H & R Industries, Pa (k,m)
Hall Mfg. Co., NJ (k)
Hartwell, H.N. & Sons, Inc., Mass (k)
Haveg Industries, Inc., Del (l)
Hawkeye Rubber Mfg. Co., Iowa (m)
Hitemp Wires, Inc., NY (k)
Hungerford Plastics Corp., NJ (k,m)
Hydrawlik Co., NJ (k,m)
Industrial Plastics Corp., Ind (k)
Irvington Varnish & Insulation Div., Minnesota Mining & Mfg. Co., NJ (k)
Jet Specialties Co., Inc., Calif (k)
Johnson Plastic Corp., Ohio (k,m)
Johnson Rubber Co., Ohio (m)
Jordan-Rogers Co., Calif (k)
Joymont Plastics, Inc., Ohio (k)
Judsen Rubber Works, Inc., Ill (m)
K S H Plastics, Inc., Mo (k)
Kaykor Industries, Inc., NJ (k)
Keystone Plastics, Inc., NJ (k)
Kraloy Plastic Pipe Co., Inc., Calif (k)
Lavelle Rubber Co., Ill (m)
Luminous Resins, Inc., Ill (k)
Lus-Trus Corp., Mich (k)
Luzerne Rubber Co., NJ (k,l)
Maloney, F.H. Co., Tex (k,m)
Martin Rubber Co., Inc., NJ (m)
Mayon Plastics, Minn (k)
Mechanical Rubber Products Co., NY (l)
Meyer, J. & Sons, Inc., Pa (k)
Mid-States Rubber Products, Inc., Ind (m)
Midwest Plastic Products Co., Ill (k)
Minnesota Rubber Co., Minn (l,m)
Minnesota Rubber & Gasket Co., Minn (m)
Moldex, NY (m)
Moore, Samuel & Co., Ohio (k)
Moxness Products, Inc., Wis (m)—Ad p 407
Multiple Extrusions, Inc., Minn (m)
Munray Products Div., Fanner Mfg. Co., Ohio (k)
National Gasket & Washer Mfg. Co., Inc., NY (k,l,m)
National Vulcanized Fibre Co., Del (k)
New England Tape Co., Inc., Mass (k)
Panelyte Div., St. Regis Paper Co., NY (k)
Parker, Stearns & Co., Inc., NY (m)
Pawling Rubber Corp., NY (k,l)
Perfex Plastics, Inc., Ill (k,m)
Pipco International Corp., Sub. of Plastiglide Mfg. Corp., Calif (k)
Plastex Co., Ohio (k)
Plastic Engineering, Inc., Ohio (k)
Plastic Packaging Co., Ill (k)
Plastiglide Mfg. Corp., Calif (k)
Plymouth Cordage Co., Mass (k)
Polyform Plastics Corp., NY (k)
Polygon Plastic Co., Ind (l)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (k)
Polyplastic Products, Inc., NJ (k)
Prince Rubber Co., Inc., NY (k,m)
Pyramid Plastics, Inc., Ill (k)
Raybestos-Manhattan, Inc., NJ (l,m)
Reliance Plastic & Chemical Corp., NJ (k)
Resistoflex Corp., NJ (k)
Rex Corp., Mass (k)
Robot Devices, Inc., Va (k)
Rogers Corp., Conn (m)
Rowland Products, Inc., Conn (k)
Ryerson, Joseph T. & Son, Inc., Ill (k)
Schaefer-Hausner Corp., NY (k)
Schwab Plastic Corp., Mich (k,m)
Seamless Rubber Co., Conn (m)
Shamban, W.S. & Co., Ind (k)
Sheller Mfg. Corp., Mich (k,l,m)
Sierra Engineering Co., Calif (m)
Southern Plastics Co., SC (k,m)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Stalwart Rubber Co., Ohio (m)
Standard Products Co., Mich (m)
Stockwell Rubber Co., Inc., Pa (k,m)
Sun Rubber Co., Ohio (m)
Sunlites Plastics, Inc., Wis (k)
Superior Plastics, Inc., Ill (k)
Supplex Co., Div. of American Hard Rubber Co., NJ (k,m)
Technical Specialties Co., NY (m)
Textron Metals Co., Ohio (k)
Thermoid Div., H.K. Porter Co., Pa (k,m)

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w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Thombert, Inc., Iowa (k)
Tri-Point Mfg. & Developing Co., NY (k)
United Shoe Machinery Corp., Mass (k,m)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)
U.S. Rubber Co., Mechanical Goods Div., Ind (k)
U.S. Stoneware Co., Ohio (k,l,m)
Victory Plastics Co., Mass (k)
Vogt Mfg. Co., NY (k)
Vulcanized Rubber & Plastics Co., Pa (m)
Western Felt Works, Ill (l,m)
Western Plastics Corp., Neb (k)
Westlake Plastics Co., Pa (k)
World Plastics, NY (k)
Yale Rubber Mfg. Co., Mich (m)
Yardley Plastics Co., Ohio (k)—Ad p 400

Fabrics, Nonwoven Synthetic

Albany Felt Co., NY
American Felt Co., Conn —Ad p 294
Beckmann, Inc., NY
Booth Felt Co., Inc., NY
Cadillac Plastic & Chemical Co., Mich
Carborundum Co., Refractories Div., NJ
Chicopee Mills, Inc., NY
Chicopee Mills, Inc., Lumite Div., NY
Continental Felt Co., NY —Ad p 300
Dexter, C.H. & Sons, Inc., Conn
Electrofilm Inc., Calif
Felters Co., Mass —Ad p 298
Ferro Corp., Fiber Glass Div., Tenn
Filpaco Industries, Inc., Ill
Foss Mfg. Co., Id
Gustin-Bacon Mfg. Co., Mo
Kendall Co., Kendall Mills Div., Mass
Masland Duraleather Co., Pa
National Felt Co., Mass
Noone Industrial Fabrics Div., Kenwood Mills, NY
Quaker City Felt Co., Pa
Russell Mfg. Co., Conn
Snyder, M.L. & Son, Inc., Pa
Star Woolen Co., NY
Stevens, J.P. & Co., Inc., NY
Tallman-McCluskey Fabrics Co., Mo
Troy Blanket Mills, NY —Ad p 286
U.S. Plywood Corp., NY
Visking Corp., Fabrics Div., Ark
Wellington Sears Co., NY
Wood Conversion Co., Minn

Fabrics, Woven

(coated)

Albany Felt Co., NY
Aldan Rubber Co., Pa
Alpha Wire Corp., NY
Andrews-Alderfer Div., Kendall Co., Ohio
Cadillac Plastic & Chemical Co., Mich
Chicopee Mills, Inc., Lumite Div., NY
Connecticut Hard Rubber Co., Conn
Continental-Diamond Fibre Corp., Del
Cordo Chemical Corp., Conn —Ad p 262
du Pont de Nemours, E.I. & Co., Inc., Del —Ad p 289
Flexible Tubing Corp., Minn
General Asbestos Gasket Mfg. Corp., Mo
General Plastics Corp., NJ
Goodrich, B.F. Industrial Products Co., Ohio
National Gasket & Washer Mfg. Co., Inc., NY
Russell Mfg. Co., Conn
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio
Twitchell, E.W., Inc., Pa
Wasco Products, Inc., Mass

Fabrics, Woven

(uncoated)

Aetna Felt Co., Inc., NY
Albany Felt Co., NY
Alox Mfg. Co., Mo
Alpha Wire Corp., NY
Atlantic Bag Co., NY
Booth Felt Co., Inc., NY
Cadillac Plastic & Chemical Co., Mich
Chicopee Mills, Inc., Lumite Div., NY
Electrofilm, Inc., Calif
Ferro Corp., Fiber Glass Div., Tenn
Foss Mfg. Co., Plastics Div., Id
Franklin Cotton Mill Co., Ohio
General Asbestos Gasket Mfg. Corp., Mo
Industrial Rayon Corp., NY
Kendall Mills Div., Kendall Co., Mass
National Gasket & Washer Mfg. Co., Inc., NY
Noone Industrial Fabrics Div., Kenwood Mills, NY
Russell Mfg. Co., Conn
Stevens, J.P. & Co., Inc., NY
Supreme Industrial Products Co., Ill
Tallman-McCluskey Fabrics Co., Mo
Thompson, H.I. Fiber Glass Co., Calif
Turner Halsey Co., NY
Twitchell, E.W., Inc., Pa
U.S. Rubber Co., NY
U.S. Rubber Co., Textile Div., NY
Vulcan Rubber Products Div., Reeves Bros., Inc., NY
Wellington Sears Co., NY

Fasteners

(see Mechanical Fasteners)

Felts, Synthetic

(see Fabrics, Nonwoven)

Felts, Wool

Aetna Felt Co., Inc., NY
Albany Felt Co., NY
American Felt Co., Conn —Ad p 294
Armstrong Cork Co., Pa
Artex Felt Co., NY
Auburn Mfg. Co., Conn
Bacon Felt Co., Mass
Beckmann, Inc., NY
Booth Felt Co., Inc., NY
Boston Felt Co., Mass
Carey, Philip Mfg. Co., Ohio
Central Felt & Fabrics Corp., NY
Coated Abrasive Products, Inc., Ohio
Continental Felt Co., NY —Ad p 300
Felters Co., Mass —Ad p 298
Fidelity Felt & Mfg. Co., NY
Filpaco Industries, Inc., Ill
General Gasket, Inc., Conn
Johns-Manville Corp., NY
Mechanical Felt & Textiles Co., NJ
National Felt Co., Mass
National Gasket & Washer Mfg. Co., Inc., NY
Noone Industrial Fabrics Div., Kenwood Mills, NY
Quaker City Felt Co., Pa
Reynolds Aluminum Supply Co., Ga
Standard Asbestos Mfg. Co., Ill
Standard Felt Co., Calif
Supreme Industrial Products Co., Ill
Wellington Sears Co., NY
Western Felt Works, Ill —Ad p 297
Wood Conversion Co., Minn

Ferrites

(see Ceramics)

Fibers, Synthetic

(see specific polymer)

Filler Metals, Welding

(electrodes, rods, etc.)

Abalon Precision Mfg. Corp., NY
Acme Stamping & Mfg. Co., Pa
Alloy Rods Co., Pa
All-State Welding Alloys Co., Inc., NY
American Brass Co., Sub. of Anaconda Co., NY
American Manganese Steel Div., American Brake Shoe Co., Ill
American Products Corp., Ill
Ampco Metal, Inc., Wis
Arcos Corp., Pa
Atlas Foundry Co., Ohio
Bridgeport Brass Co., Conn —Ad p 152
Champion Rivet Co., Ohio
Crucible Steel Co. of America, Pa
Dana Corp., Auburn Div., Ind
Electric Steel Foundry Co., Ore
Eutectic Welding Alloys Corp., NY
General Dynamics Corp., Liquid Carbonic Div., Ill
Harnischfeger Corp., Wis
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., Ind
Ideal Can Co., Mass
Ingersoll Products Div., Borg-Warner Corp., Ill
International Nickel Co., Inc., NY
Johnson, A. & Co., Inc., NY
K S M Products, Inc., NJ
Kaiser Aluminum & Chemical Sales, Inc., Ill
Lincoln Electric Co., Ohio
Linde Co., Div. of Union Carbide Corp., NY
Lukens Steel Co., Pa
Magnesium Co. of America, Ind
Magnesium Products of Milwaukee, Inc., Wis
Magnesium Elektron, Inc., NY
Manganese Steel Forge Co., Pa
Marquette Mfg. Co., Inc., Minn
McDowell Mfg. Co., Pa
Metal Goods Corp., Mo
Metal & Thermit Corp., NJ
Midwest Stamping & Mfg. Co., Ohio
Morrisville Foundry Co., Inc., Vt
Narragansett Boiler Works, Inc., RI
Page Steel & Wire Div., American Chain & Cable Co., Pa
Somerset Foundry & Machine Co., Pa
Southern Metal Products Co., La
Titan Metal Mfg. Co., Pa —Ad p 388
Victor Equipment Co., Calif
Wall Colmonoy Corp., Stainless Process Div., Mich
Waterman Industries, Inc., Calif
Wesbar Stamping Corp., Wis
Whitehead Metal Products Co., Inc., NY

Film

(see specific plastic or rubber)

Fluorocarbon Plastics

aaRBee Plastic Co., Calif (y)
Acme Resin Corp., Ill (p)
Allegheny Plastics, Inc., Pa (bb,cc,dd,ee)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (y)
Auburn Plastic Engineering, Ill (t,bb,cc,dd,ee)
Automotive Rubber Co., Inc., Mich (y,cc)
Bakelite Co., Div. of Union Carbide Corp., NY (p)
Bamberger, Claude P., Inc., NJ (y)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Chemical Coatings and Engineering Co., Inc., Pa (x)
Chicago Gasket Co., Ill (t,bb,cc,dd,ee)
Colonial Kolonite Co., Ill (bb,cc,dd,ee)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Crane Packing Co., Ill (t,bb,cc,dd,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,dd,ee)
Dixon Corp., RI (y,bb,cc,dd,ee)
Dodge Fibers Corp., NY (s,t,cc,dd)
du Pont de Nemours, E.I. & Co., Inc., Del (p,s,t,y)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Enflo Corp., NJ (t,bb,cc,dd,ee)
Fluoro-Plastics, Inc., Div. of Flexrock Co., Pa (bb,cc,dd,ee)
Galigher Co., Utah (bb,cc,dd,ee)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
General Gasket, Inc., Conn (t,cc)
General Plastics Corp., NJ (t,x)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
H & R Industries, Pa (bb,cc,dd,ee)
Halogen Insulator & Seal Corp., Ill (bb,cc,dd,ee)
Haveg Industries, Inc., Del (bb,cc,ee)
Hitemp Wires, Inc., NY (ee)
Insulation Mfrs. Corp., Ill (t,bb,cc,dd,ee)
Kurz Kasch, Inc., Ohio (y)
Maloney, F.H. Co., Tex (y)
Minnesota Mining & Mfg. Co., Minn (y)
Minnesota Mining and Mfg. Co., Chemical Div., Minn (p,y)
Norrich Plastics Corp., NY (bb,ee)
Permacel-LePage's, Inc., NJ (t,cc,ee)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (t,bb,cc,dd,ee)—Ad p 230
Prince Rubber Co., Inc., NY (bb,cc,ee)
Raybestos - Manhattan, Inc., Plastic Products Div., Conn (bb,cc,dd)—Ad p 256
Resistoflex Corp., NJ (bb,cc,ee)
Russell Mfg. Co., Conn (s)
Sanford Plastics Corp., NY (bb,ee)
Shamban, W.S. & Co., Calif (p,t,x,y,bb,cc,dd,ee)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (t,y,bb,cc,dd,ee)
Staver Co., Inc., NY (cc,dd)
Thombert, Inc., Iowa (bb,cc,dd,ee)
Tri-Point Mfg. & Developing Co., NY (bb)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (t,bb,cc,dd,ee)
U.S. Stoneware Co., Ohio (ee)
Visking Corp., Plastics Div., Ind (t)
Vulcan Rubber Products Div., Reeves Bros. Inc., NY (bb,dd,ee)
Westlake Plastics Co., Pa (t,y,bb,cc,dd,ee)

Fluorocarbon Rubber

(fluoroelastomers)

Allis Rubber Div., Chicago-Allis Mfg. Corp., Ill (p)
Automotive Rubber Co., Inc., Mich (cc,dd)

Belko Corp., Md (y)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings and Engineering Co., Pa (x,y)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (y,cc,dd)
Connecticut Hard Rubber Co., Conn (bb,cc,dd,ee)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Dodge Fibers Corp., NY (s,t,cc,dd)
Dow Corning Corp., Mich (p)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I. & Co., Inc., Del
(cc)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,cc)
Hitemp Wires, Inc., NY (ee)
Hooker Chemical Corp., NY (p)
Johns-Manville Corp., Dutch Brand Div. NY (cc)
Maloney, F.H. Co., Tex (y)
Minnesota Mining & Mfg. Co., Minn (p)
Minnesota Mining and Mfg. Co., Chemical Div., Minn (p,y)
Moxness Products, Inc., Wis
(cc)
Norrich Plastics Corp., NY (bb,dd,ee)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Rogers Corp., Conn (u,y)
Russell Mfg. Co., Conn (s)
Trostel, Albert Packing, Ltd., Wis (y)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Co., Ill (y,cc,dd,ee)
Westlake Plastics Co., Pa (bb,cc,dd)

Foams

(see specific plastic or rubber)

Foil

(see specific metal)

Forgings

(see also Cold Headed Parts)

Abegg & Reinhold Co., Calif (g)
Accurate Brass Corp., NY (b)
Alco Products, Inc., NY (g)
Allegheny Ludlum Steel Corp., Pa
(g)
Aluminium Ltd. Sales, Inc., NY (a)
Aluminum Co. of America, Pa (a,e)
Amalgamated Steel Corp., Ohio (g)
American Brass Co., Sub. of Anaconda Co., NY
(b)
American Car & Foundry Div., ACF Industries, Inc., NY (g)
American Chain & Cable Co., Pa (g)
American Forge & Mfg. Co., Pa (g)
American Manganese Bronze Co., Pa (b)
American Steel Foundries, Ill (g)
Amforge Div., American Brake Shoe Co., Ill (a,g)
Ampco Metal, Inc., Wis (b)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Armco Steel Corp., Sheffield Div., Mo (g)
Atlas Drop Forge Co., Mich (f,g,h)
Auld, D.L. Co., Ohio (a)
Baldt Anchor, Chain & Forge Div., Boston Metals Co., Pa (a,b,g)
Bay City Forge Co., Pa (g)
Bethlehem Steel Co., Pa (g)
Billings & Spencer Co., Conn (a,b,g,h)
Bingham Herbrand Corp., Herbrand Div., Ohio (g)
Blakeslee Forging Co., Conn (a,b,c,d, f,g,h)
Bohn Aluminum & Brass Corp., Mich (a,b)
Braeburn Alloy Steel Corp., Pa (g)
Brewer-Titchener Corp., NY (a,g)
Bridgeport Brass Co., Conn
(a,b,f)—Ad p 152
Bristol Brass Corp., Conn (b)
California Drop Forge Co., Calif (g)
Cameron Iron Works, Inc., Special Products Div., Tex
(c,f,g,h)—Ad p 411
Canton Forge & Axle Works, Poor & Co., Ohio (f,g)
Carbo Tool & Die Co., Ohio (c,f)
Carpenter Steel Co., Pa (f,g)
Champion Rivet Co., Ohio (b,c,g)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (a,b)
Chicago Extruded Metals Co., Ill (b)
Cincinnati Forging Co., Ohio (b)
Clapp, E.D. Mfg. Co., Inc., NY (b,c, f,g)
Cleveland Cap Screw Co., Ohio (a,b, f,g,h)
Cleveland City Forge Co., Ohio (a, c,f,g,h)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (g)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (g)
Columbus Bolt & Forging Co., Ohio (g)
Commercial Shearing & Stamping Co., Ohio (g)
Composite Forgings, Inc., Mich (g)
Copper & Brass Sales, Inc., Mich (a,b)
Crucible Steel Co. of America, Pa (c,f,g)
Crucible Steel Co. of America, Titanium and Vacuum Metals Product Div., Pa (b,c,f,g,h)
Curtiss-Wright Corp., Metals Processing Div., NY (a,b,f,g)
Cyril Bath Co., Ohio (a,g)
Dirilyte Co. of America, Inc., Ind (a,b,e)
Doehler-Jarvis Div., National Lead Co., Ohio (a)
Edgecomb Steel & Aluminum Corp., NJ (g)
Electric Auto-Lite Co., Ohio (c)
Electric Materials Co., Pa (b)
Electric Steel Foundry Co., Ore (f,g)
Endicott Forging & Mfg. Co., Inc., NY (b,f,g,h)
Eureka Electric Products Co., Pa (a, b,g)
Fairmount Tool & Forging, Inc., Sub. of Houdaille Industries, Inc., Ohio (g)
Finkl, A. & Sons Co., Ill (g)
Frasse, Peter A. & Co., Inc., NY
(a,g)—Ad p 92
Fromson Orban Co., Inc., NY (a)
Garden State Forge Co., NJ (a,b,c,f, g,h)
General Drop Forge Corp., NY (g)
Giant Grip Mfg. Co., Wis (a,g,h)
Greene, G.G. Corp., Pa (g)
Harrisburg Steel Co., NY (g)
Harvey Aluminum Sales, Inc., Calif (a,e,g)
Heppenstall Co., Pa (g,h)
Hobbs, Clinton E. Co., Mass (c,g)
Hunter-Douglas Aluminum Div., Bridgeport Brass Co., Calif (a,b)
Huron Forge & Machine Co., Mich (a,b,g)
Illinois Forge, Inc., Ill (g)
Illinois Iron & Bolt Co., Ill (g)
Indiana Forge & Machine Co., Ind (g)
Interstate Drop Forge Co., Wis (f,g)
Irwin-Sensenich Corp., Pa (g)
Isaacson Iron Works, Wash (g)
Janney Cylinder Co., Pa (b)
Jessop Steel Co., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kelsey-Hayes Co., Mich (g,h)
Keystone Forging Co., Pa (g)
Kovar, John R. Mfg. Co., Inc., Minn (g)
Kropp Forge Co., Ill (g,h)
Ladish Co., Wis (a,b,c,e,f,g,h)
Larson, Charles E. & Sons, Inc., Ill (a,b,c,g)
Larson Tool & Stamping Co., Mass (a,b,c,e,f,g,h,j)
Latrobe Steel Co., Pa
(g)
Lenape Hydraulic Pressing & Forging Co., Pa
(a,b,g)—Ad p 396
Lindell Drop Forge Co., Mich (g)
Machinery Forging Co., Ohio (g)
Mallory, P.R. & Co., Inc., Ind (b)
Manganese Steel Forge Co., Pa (g)
McCarter Iron Works, Inc., Pa (g)
McInnes Steel Co., Pa (f,g,h)
McNally Pittsburg Mfg. Co., Kan (g)
Melling Forging Co., Mich (f)
Midvale-Heppenstall Co., Pa (c,f,g)
Milwaukee Forge & Machine Co., Wis (g)
Montague Machine Co., Mass (g)
Moore Dry Dock Co., Calif (g)
Mueller Brass Co., Mich
(a,b)—Ad p 397
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Murray Tube Works, Inc., NJ (a,b,g)
National Cored Forging Div., Bridgeport Brass Co., Conn (a,b)
National Forge & Ordnance Co., Pa (g)
National Lead Co., NY (a,b,h)
National Supply Co., Industrial Products Div., Calif (g)
National Tube Div., U.S. Steel Corp., Pa, (g)
Norcross, C.S. & Sons Co., Ill (g)
Ohio Forge & Machine Corp., Ohio (c,f,g)
Olderman Mfg. Corp., Conn (b)
Olds Alloys Co., Calif (b)
Pacific States Steel Corp., Calif (g)
Park Drop Forge Co., Ohio (g)
Pattin Mfg. Co., Ohio (g)
Pencoyd Steel & Forge Corp., Pa (c,g)
Peninsular Steel Co., Mich (g)
Pettibone Mulliken Corp., Ill (g)
Phoenix Mfg. Co., Ill (g)
Pittsburgh Forgings Co., Pa (a,f,g)
Poor & Co., Canton Forge & Axle Works, Ohio (g)
Porter, H.K., Inc., Mass (g)
Porter, H.K., Inc., Forge & Fittings Div., Ohio (a,g)
Rankin Forge Co., Pa (c,g)
Republic Steel Corp., Ohio
(g)
Revere Copper & Brass, Inc., NY (a,b)
Rhode Island Tool Co., RI
(a,b,e,g)—Ad p 406
Rockford Bolt & Steel Co., Ill (g)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
St. Pierre Chain Corp., Mass (a,f,g)
Scovill Mfg. Co., Mill Products Div., Conn
(a,b)
Seltzer, George H. & Co., Pa (g)
Sharpsville Steel Fabricators, Inc., Pa (g)
Sherman & Reilly, Inc., Tenn (a,g)
Skookum Co., Inc., Ore (g)
Smith-Armstrong Forge, Inc., Ohio (g)
Standard Forge & Axle Co., Inc., Ala (g)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (g)
Star Heel Plate Co., Inc., NJ (g)
Steel, R. & Sons, Inc., NY (f,g)
Steel Improvement and Forge Co., Ohio (a,g)
Struthers Wells Corp., NY (f,g)
Taylor Forge & Pipe Works, Ill (a,c, f,g,h)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Thompson Products, Inc., Valve Div., Ohio (f,g)
Titan Metal Mfg. Co., Pa
(a,b)—Ad p 388
Tool & Mfg. Co., Inc., Pa (g)
Transue & Williams Steel Forging Corp., Ohio (b,c,f,g,h)
Tube Turns, Div. of Chemetron Corp., Ky (a,b,c,e,f,g,h)
Union Forging Co., NY (g)
United Forge Co., Mich (c,g)
United Shoe Machinery Corp., Mass (a)
U.S. Steel Corp., Pa
(g)
Universal-Cyclops Steel Corp., Pa (f,g
Uniworld Research Corp. of America Ohio (c)
Vanadium-Alloys Steel Co., Pa (g)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (g)
Walker Forge, Inc., Wis (g)
Weatherhead Co., Ind (a,b,g,h)
Weber-Knapp Co., NY (a)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
(a,b,c,f,g,h)
Wilcox Forging Corp., Pa (e,f,g,h)
Wilde Drop Forge & Tool Co., Inc. Mo (g)
Wilde Tool Co., Inc., Kan (g)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Williams, J.H. & Co., NY (a,b,e,f,g,h)
Wyman-Gordon Co., Mass (a,e,f,g,h)
Zeller Corp., Ohio (g)
Ziv Steel & Wire Co., Ill (g)

Forsterite

(see Ceramics)

Furanes

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p)
Atlas Mineral Products Co., Pa (p,x)
Catalin Corp. of America, NY (p)
Durez Plastics Div., Hooker Chemical Corp., NY
(p)
Electro Chemical Engineering & Mfg. Co., Pa (cc)
Foss Mfg. Co., Plastics Div., Id (x)
Furane Plastics, Inc., Calif (p,x)
Haveg Industries, Inc., Del (p,bb,cc, ee)
Knight, Maurice A., Ohio (p,x)
Plastics Engineering Co., Wis
(p)
Reichhold Chemicals, Inc., NY (p)
U.S. Stoneware Co., Ohio (y)

Galvanized Metals

(see Precoated Metals)

Galvanizers

Acme Galvanizing Co., Calif
Advance Galvanizing Co., Calif
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
American Smelting & Refining Co., NY
American Tinning & Galvanizing Co., Pa
Armco Steel Corp., Ohio
Armor Galvanizing Works, Inc., Calif
Atlantic Steel Co., Ga
Atlas Galvanizing Co., Calif
Bessemer Galvanizing Works, Ala
Bethlehem Steel Co., Pa
Boyles Galvanizing & Plating Co., Tex
Buffalo Steel Corp., NY
Byers, A.M. Co., Pa
Cincinnati Pump & Mfg. Co., Inc., Ohio
Clayton & Lambert Mfg. Co., Ky
Clifton Conduit Corp., Md
Columbian Steel Tank Co., Mo
Continental-Emsco Co., Calif
Debevoise Co., NY
Designers Metal Corp., Ill
Detroit Brass & Malleable Co., Mich
Dow Chemical Co., Tex
Empire Metal Co., NY
Enterprise Galvanizing Co., Pa
Fanner Mfg. Co., Ohio
Farrelloy Co., Pa
Fenestra, Inc., Mich
Green-Walker Galvanizing Co., Inc., La
Gregory, Thomas Galvanizing Works, NY
Hanlon-Gregory Galvanizing Co., Pa
Haywilk Galvanizing, Inc., La
Hill, James Mfg. Co., RI
Illinois Edison Porcelain Div., McGraw-Edison Co., Ill
Independent Galvanizing Co., NJ
Joslyn Mfg. & Supply Co., Ill
Joslyn Pacific Co., Calif
Kent County Galvanizing Co., RI
Kinkead Industries, Inc., Ill
Kobel, W.R. Sheet Metal Products, Utah
Koven, L.O. & Bro., Inc., NJ
Lawson, F.H. Co., Ohio
Lehigh Structural Steel Co., Pa
Lewis Bolt & Nut Co., Minn
Line Material Industries, McGraw-Edison Co., Pa
Los Angeles Galvanizing Co., Calif
Malleable Iron Fittings Co., Conn
Maze, W.H. Co., Ill
Metal Coating Corp., Ill
Metallizing Co. of Los Angeles, Inc., Calif
Metalplate Co., Inc., Ala
Missouri Rolling Mill Corp., Miss
National Galvanizing Co., Pa
National Gasket & Washer Mfg. Co., Inc., NY
National Telephone Supply Co., Ohio
New Jersey Zinc Co., NY
Noland Tank & Galvanizing Co,, Tenn
Northwestern Steel & Wire Co., Ill
Nowery J. Smith Bolt & Supply Co., Tex
Nylok Corp., NJ
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa
Penn Metal Co., Inc., W.Va
Pennsylvania Range Boiler Co., Pa
Promat Div., Poor & Co., Ill
Reed & Prince Mfg. Co., Mass
Republic Steel Corp., Ohio
Reynolds Wire Div., National-Standard Co., Ill
Riverside Foundry & Galvanizing Co., Mich
Roebling's. John A. Sons Corp., NJ
Rohnco, Inc., Ill
Ryerson, Joseph T. & Son, Inc., Ill
San Francisco Galvanizing Works, Calif
Sawhill Tubular Products, Inc., Pa
Scaife Co., Pa
Schlueter Mfg. Co., Mo
Sealube Co., Mass
Sharon Steel Corp., Pa
Sherman & Reilly, Inc., Tenn
Southern Galvanizing Co., Md
Southern Metal Products Co., La
Spencer Nahm Co., Calif
Stevens, Frederic B., Inc., Mich
Superior-Pacific Galvanizing Co., Calif
WLS Stamping Co., Ohio
Wessels Co., Mich
Wilcox-Crittenden Div., North & Judd Mfg. Co., Conn
Witt Cornice Co., Galvanizing Div., Ohio
Wood, John Co., Ill
Worcester Wire Works Div., National-Standard Co., Mass
Young & Greenawalt, Ind

Germanium

American Metal Climax, Inc., NY (o,w,aa)
American Zinc Sales Co., Mo (q)
Belmont Smelting & Refining Works, Inc., NY
(aa)
Eagle-Picher Co., Ohio (w,aa)
Hardy, Charles, Inc., NY (aa)
Parker Metal Goods Co., Mass (bb)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (w)
Ullmann, Inc., Wis (o,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
(aa)

Glass, Alumino-Silicate

Corning Glass Works, NY
(r,aa,bb,ee)
Kimble Glass Co., Sub. of Owens-Illinois Glass Co., Ohio (r,aa,bb,ee)
Kopp Glass, Inc., Pa (r)
L. O. F. Glass Fibers Co., Ohio (s)
Lancaster Glass Corp., Ohio (r)
Pittsburgh Plate Glass Co., Pa (s)
Russell Mfg. Co., Conn (r,s)

Glass, Borosilicate

Anchor Hocking Glass Corp., Ohio (r)
Applied Instruments, Inc., NY (z,bb, cc,ee)
Bausch & Lomb Optical Co., NY (r)
Corning Glass Works, NY
(r,z,aa,bb,cc,ee)—Ad p 295
Fish-Schurman Corp., NY (bb,ee)
Friedrich & Dimmock, Inc., NJ (r,s)
Gustin-Bacon Mfg. Co., Mo (r,s)
Kimble Glass Co., Sub. of Owens-Illinois Glass Co., Ohio (r,aa,bb,ee)
Kopp Glass, Inc., Pa (r)
Lancaster Glass Corp., Ohio (r)
Mansol Ceramics Co., NJ (r,aa)
Marsco Mfg. Co., Ill (r)
Modiglass Fibers, Inc., NJ (s)
Penberthy Instrument Co., Wash (r)
Pittsburgh Corning Corp., Pa (u)
Pittsburgh Plate Glass Co., Pa (s)
Pittsburgh Plate Glass Co., Fiber Glass Div., Pa
(s)
Russell Mfg. Co., Conn (s)
Semon Bache & Co., NY (z,cc,ee)
Shull Bros. Glass Co., NJ (r,ee)
Thompson, H.I. Fiber Glass Co., Calif
(s)

Glass, Lead Alkali Silicate

Bausch & Lomb Optical Co., NY (r)
Corning Glass Works, NY
(r,aa,bb,ee)—Ad p 295
Kimble Glass Co., Sub. of Owens-Illinois Glass Co., Ohio (r,aa,bb,ee)
Kopp Glass, Inc., Pa (r)
Lancaster Glass Corp., Ohio (r)
Mansol Ceramics Co., NJ (r,aa)
Pemberthy Instrument Co., Wash (r,z)
Semon Bache & Co., NY (z,cc,ee)

Glass, 96% Silica

Amersil Quartz Div., Engelhard Industries, Inc., NJ
(c,s,z,aa,bb,cc,ee)
Applied Instruments, Inc., NY (z,cc, ee)
Corning Glass Works, NY
(r,z,aa,bb,cc,ee)
L.O.F. Glass Fibers Co., Ohio (s)
Fish-Schurman Corp., NY (bb,ee)
Marsco Mfg. Co., Ill (r)
Russell Mfg. Co., Conn (r,s)
Thompson, H.I. Fiber Glass Co., Calif
(s)

Glass, Silica

Applied Instruments, Inc., NY (z,cc, ee)
Corning Glass Works, NY
(r,z,aa,cc)—Ad p 295
Friedrich & Dimmock, Inc., NJ (r)
L.O.F. Glass Fibers Co., Ohio (s)
McGean Chemical Co., Ohio
Modiglass Fibers, Inc., NJ (s)
Pyrosil, Inc., Ohio (r,z,aa,bb,cc,ee)
Semon Bache & Co., NY (z,cc,ee)
Thompson, H.I. Fiber Glass Co., Calif
(s)

Glass, Soda-Lime

Anchor Hocking Glass Co., Ohio (r)
Applied Instruments, Inc., NY (z,bb, cc,ee)
BLC Porous Materials Co., Calif (r,z, cc)
Bausch & Lomb Optical Co., NY (r,s)
Corning Glass Works, NY
(r,aa,bb,ee)—Ad p 295
Erie Scientific Corp., NY (cc)
Friedrich & Dimmock, Inc., NJ (r,s, bb,ee)
Kimble Glass Co., Sub. of Owens-Illinois Glass Co., Ohio (r,aa,bb,ee)
Kopp Glass, Inc., Pa (r)
Lancaster Glass Corp., Ohio (r)
Mansol Ceramics Co., NJ (r,aa)
Modiglass Fibers, Inc., NJ (s)
Pittsburgh Plate Glass Co., Pa (z,cc)
Semon Bache & Co., NY (z,cc,ee)
Shull Bros. Glass Corp., NJ (r,bb,ee)
Thompson, H.I. Fiber Glass Co., Calif (s)

Glass Coatings

(see Inorganic Coatings)

Glass for Plastics Reinforcement

Bassichis Co., Ohio
Coast Mfg. & Supply Co., Calif
Electrofilm, Inc., Calif
Exeter Mfg. Co., NY
Ferro Corp., Fiber Glass Div., Tenn
Flexfirm Products, Calif
Foss Mfg. Co., Plastics Div., Id
Johns-Manville Corp., NY
L.O.F. Glass Fibers Co., Ohio
Modiglass Fibers, Inc., NJ
Owens-Corning Fiberglas Corp., Ohio
Pittsburgh Plate Glass Co., Fiber Glass Div., Pa
—Ad p 249
Pyrosil, Inc., Ohio
Ren Plastics, Inc., Mich
Rezolin, Inc., Calif
Russell Mfg. Co., Conn
Standard Insulation Co., Plastics Div., NJ
Tallman-McCluskey Fabrics Co., Mo
Thompson, H.I. Fiber Glass Co., Calif
Union Carbide Metals Co., Div. of Union Carbide Corp. NY
U.S. Polymeric Chemicals, Inc., Conn

Gold and Its Alloys

Advance Stamping Co., Mich (dd)
Alpha Metals, Inc., NJ (t)
American Metal Climax, Inc., NY (w,aa)
American Platinum & Silver Div., Engelhard Industries, Inc., NY
(n,o,v,z,bb,cc,dd,ee,ff)
American Platinum Works, NJ (z)
American Silver Co., NY (y,dd,ee,ff)
American Smelting & Refining Co., NY (o)
Anaconda Co., NY (o)
Anchor Metal Co., Inc., NY (w)
Baker & Co., Inc., NJ (n,o,v,w,z,bb,cc, dd)
Bart Mfg. Corp., NJ (aa)
Bishop, J. & Co. Platinum Works, Pa
(ff)
Deringer Metallurgical Corp., Ill (cc, ee,ff)
Eastern Smelting & Refining Corp., Mass (n,o,v,w,z,aa,bb,cc,dd,ee,ff)
General Plate Div., Metals & Controls Corp., Mass (n,v,z,bb,cc,dd)
Goldsmith Bros., S. & R. Co., Ill (n,o,v,w,z,aa,bb,cc,dd,ff)
Hagstoz, T.B. & Son, Pa (n,cc,dd,ff)
Handy & Harman, NY
(n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hanovia Chemical & Mfg. Co., NJ (aa)
Hardy, Charles, Inc., NY (aa)
Hastings & Co., Inc., Pa (v)
Hayden Wire Works, Inc., Mass (ff)
Improved Seamless Wire Co., RI (bb, cc,dd,ee,ff)
Lakeland Industries, Minn (z)
Leach & Garner Co., Industrial Div., Mass (n,o,v,z,bb,cc,dd,ee,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (n,o,v,z,bb,dd, ee,ff)
Metals & Controls Corp., Mass (n,o, q,v,w,z,bb,cc,dd,ee,ff)

Metals Disintegrating Co., Inc., NJ (aa)—Ad p 415
Nesor Alloy Products Co., NJ (dd,ff)
Ney, J.M. Co., Industrial Div., Conn (v,z,bb,cc,dd,ee,ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Peerless Roll Leaf Co., Inc., NJ (v,dd)
Sel-Rex Corp., NJ (n,aa)
Standard Metals Corp., Mass (n,o,v,z, bb,cc,dd,ee,ff)
Technic, Inc., RI (aa)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (aa, cc,dd,ff)
Wildberg Bros. Smelting & Refining Co., Calif (n,o,v,w,z,aa,bb,cc,dd,ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)

Graphite

(see Carbon)

Gray Iron

(see Iron)

GR-S Rubber

(see Styrene-Butadiene Rubber)

Hard Facing Alloys

Air Reduction Sales Co., NY
Alloy Rods Co., Pa
Alloy Surfaces Co., Inc., Del
All-State Welding Alloys Co., Inc., NY
American Manganese Steel Div., American Brake Shoe Co., Ill
American Smelting & Refining Co., NY
Champion Rivet Co., Ohio
Cleveland Hard Facing Co., Inc., Ohio
Crucible Steel Co. of America, Pa
Electric Steel Foundry Co., Ore
Fansteel Metallurgical Corp., Ill
General Electric Co., NY
Harnischfeger Corp., Wis
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., Ind
Hobart Bros. Co., Ohio
Janney Cylinder Co., Pa
Kennametal, Inc., Pa —Ad p 301
Kinkead Industries, Inc., Ill
Lincoln Electric Co., Ohio
Lincoln Iron Works, Vt
Marquette Mfg. Co., Inc., Minn
McKay Co., Pa
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metal-Cladding, Inc., NY
Metallizing Co. of Los Angeles Inc., Calif
Metallizing Engineering Co., Inc., NY —Ad p 336
Moore Drydock Co., Calif
Overmyer Mould Co., Inc., Ind
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa
Republic Steel Corp., Ohio
Sommer Metalcraft Corp., Ind
Stevens, Frederic B., Inc., Mich
Stoody Co., Calif
Tiarco Corp., NJ
Uniworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa
Victor Equipment Co., Calif
Wall Colmonoy Corp., Stainless Process Div., Mich

Hard Surfaces for Metals

(see Diffusion Coatings; Hard Facing Alloys)

High Pressure Laminates

(see Laminates)

Hot Melt Coatings

(see Organic Coatings)

Hypalon

(see Chlorosulfonated Polyethylene Rubber)

Immersion Coatings, Chemical

(incl. Electroless)

Allied Research Products, Inc., Md
All-State Welding Alloys Co., Inc., NY
Amchem Products, Inc., Pa
Automotive Rubber Co., Inc., Mich
Biddle Screw Products Co., Ind
Birchwood Chemical Co., Minn
Chemical Development Corp., Mass
Dollin Corp., NJ
Electro Chemical Engineering & Mfg. Co., Pa
General American Transportation Corp., Ill
Industrial Chromium Corp., Mass
Lithcote Corp., Ill
MacDermid, Inc., Conn
Magnesium Co. of America, Ind
Mariane Development Co., Inc., NY
Merix Chemical Co., Ill
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metal-Cladding, Inc., NY
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Nylok Corp., NJ
Octagon Process, Inc., NY
Parker Rust Proof Co., Mich
Plume & Atwood Mfg. Co., Conn
Promat Div., Poor & Co., Ill
Reynolds Chemical Products Co., Mich
Rustproofing & Metal Finishing Corp., Mass
St. Eloi Corp., Ohio
Stevens, Frederic B., Inc., Mich
Tickle, Arthur Engineering Works, Inc., NY
Turco Products, Inc., Calif
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
WLS Stamping Co., Ohio

Impact Extrusions

(cold extrusions)

Allied Products Corp., Mich (g)
Almco Steel Products Corp., Ind (b,g)
Aluminum Co. of America, Pa (a)
Bridgeport Brass Co., Conn (a)
Cliff Mfg. Co., Ohio (a,e)
Curtiss-Wright Corp., NY (g)
Cyril Bath Co., Ohio (g)
Division Lead Co., Ill (d)
Dow Chemical Co., Dow Metal Products Co. Div. Mich (e)
Fletcher Enamel Co., W.Va (a,b,c,d, e,f)
Fromson Orban Co., Inc., NY (a)
Harvey Aluminum Sales, Inc., Calif (a)
Heintz Mfg. Co., Pa (g)
Hunter-Douglas Aluminum Div., Bridgeport Brass Co., Calif (a)
Impact Extrusions, Inc., Ind (a)
Impax, Inc., Mo (a,b,e,j)
Ladish Co., Wis (a,b,c,e,f,g,h)
Leake Engineering Co., Mich (a,b,d,g)
Magline, Inc., Mich (e)
Magnesium Co. of America, Ind (a,e)
Mueller Brass Co., Mich (a,b,g)—Ad p 397
Pheoll Mfg. Co., Ill (a,b,c,g)
Republic Steel Corp., Ohio (g)
Rockwell - Standard Corp., Bossert Stamping Div., NY (g)
Sherman & Reilly, Inc., Tenn (e,f,g)
Sun Tube Corp., NJ (a,b,e)
Thompson Products, Light Metals Div., Ohio (a)
Townsend Co., Fasteners Div., Pa (a, b,g)
United Shoe Machinery Corp., Mass (a)
Wirz, A.H., Inc., Pa (a,b,d,j)
Worcester Pressed Steel Co., Mass (a)

Impregnated or Compressed Wood

(see Wood)

Impregnation Coatings

(see Organic Coatings)

Indium and Its Alloys

Alpha Metals, Inc., NJ (o,q,t,w,bb,cc, dd)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (n,o,q,v,w,bb,cc,dd,ff)
Anaconda Co., NY (aa)
Belmont Smelting & Refining Works, Inc., NY (o)
Cerro de Pasco Sales Corp., NY (o,w)
Division Lead Co., Ill (o,v,cc,ff)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Federated Metals Div., American Smelting and Refining Co., NY (o,q, v,w,bb,cc,dd,ff)
General Plate Div., Metals & Controls Corp., Mass (dd)
Glidden Co., Chemicals-Pigments-Metals Div., Md (aa)—Ad p 391
Goldsmith Bros. Smelting & Refining Co., Ill (o,q)
Handy & Harman, NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hardy, Charles, Inc. NY (aa)
Indium Corp. of America, NY (n,o,q,v,w,z,aa,bb,cc,dd,ff) — Ad p 154
International Minerals and Metals Corp., NY (w)
Kelsey-Hayes Co., Utica Metals Div., NY (w)
Nesor Alloy Products Co., NJ (dd,ff)
Sel-Rex Corp., NJ (aa)
Utica Metals Div., Kelsey-Hayes Co., NY (w)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (dd, ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)

Ingots

(see specific metal)

Injection Moldings

(see Moldings)

Inorganic Coatings, Ceramic

(formulations)

Bisonite Co. Inc., NY
California Metal Enameling Co., Calif
Centralab Div., Globe Union, Inc., Wis
Chicago Vitreous Corp., Div. of Eagle-Picher Co., Ill
Continental Coatings Corp., Ohio
Cooley, W.J. & Co., Tenn
Dennis Chemical Co., Mo
Douglas & Sturgess, Calif

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

du Pont de Nemours, E.I. & Co., Inc., Del
Dyna-Therm Chemical Corp., Calif
—Ad p 334
Electrolizing Co., Ill
France, J.H. Refractories Co., Pa
Harshaw Chemical Co., Ohio
Hayden Wire Works, Inc., Mass
Hitemp Wires, Inc., NY
Hommel, O. Co., Pa
Ingram-Richardson, Inc., Ind
Kraus Research Labs, Md
Laboratory Equipment Corp., Mich
Linde Co., Div. of Union Carbide Corp., NY
Lithium Corp. of America Inc., Minn
Metal & Thermit Corp., NJ
Metallizing Engineering Co., Inc., NY
—Ad p 330
Norton Co., Mass
Refractory & Insulation Corp., NY
Sauereisen Cements Co., Pa
Solar Aircraft Co., Calif
Thermal Refractories Corp., NJ
Zirconium Corp. of America, Ohio
Zophar Mill, Inc., NY

Inorganic Coatings, Ceramic

(coaters)

American Emblem Co., Inc., NY
Bevan Co., Calif
Bisonite Co., Inc., NY
Brooks & Perkins, Inc., Mich
—Ad p 410
California Metal Enameling Co., Calif
Centralab Div., Globe Union Inc., Wis
Continental Coatings Corp., Ohio
Cooley, W.J. & Co., Tenn
Dyna-Therm Chemical Corp., Calif
Electrofilm, Inc., Calif
Electrolizing Co., Ill
Emerson & Cuming, Inc., Mass
Enamel Products Co., Ohio
Erie Ceramic Arts Co., Pa
Fletcher Enamel Co., W.Va
Hayden Wire Works, Inc., Mass
Ingram-Richardson, Inc., Ind
Lancaster Glass Corp., Ohio
Linde Co., Div. of Union Carbide Corp., NY
Metal-Cladding, Inc., NY
Metallizing Co. of Los Angeles, Inc., Calif
Metaplast Process, Inc., NY
Norton Co., Mass
Russell Mfg. Co., Conn
St. Eloi Corp., Ohio
Solar Aircraft Co., Calif
Sylvester & Co., Ohio
Thermo Materials, Inc., Calif
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
Zirconium Corp. of America, Ohio

Inorganic Coatings, Porcelain or Glass

(formulations)

Bettinger Corp., Mass
California Metal Enameling Co., Calif
Chemical Coatings and Engineering Co., Pa
Chicago Vitreous Corp., Div. of Eagle-Picher Co., Ill
Dennis Chemical Co., Mo
Du-Co Ceramics Co., Pa
du Pont de Nemours, E.I. & Co., Inc., Del
Dyna-Therm Chemical Corp., Calif
Erie Ceramic Arts Co., Pa
—Ad p 336
Ferro Corp., Ohio
Harshaw Chemical Co., Ohio
Hitemp Wires, Inc., NY
Hommel, O. Co., Pa
Independence Stove & Mfg. Co., Mo
Ingram-Richardson, Inc., Ind
Lithium Corp. of America Inc., Minn
Metal-Cladding Inc., NY
Pemco Corp., Md
Pierce & Stevens Chemical Corp., NY
Sauereisen Cements Co., Pa

Inorganic Coatings, Porcelain or Glass

(enamelers)

American Valve & Enameling Corp., Ind
Applied Instruments, Inc., NY
Barrows Porcelain Enamel Corp., Ohio
Bettinger Corp., Mass
Bevan Co., Calif
California Metal Enameling Co., Calif
Cleveland Porcelain Enameling Co., Ohio
Emerson & Cuming, Inc., Mass
Enamel Products Co., Ohio
Erie Ceramic Arts Co., Pa
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Erie Enameling Co., Pa
Ervite Co., Pa
Ferro Enameling Co., Calif
Fletcher Enamel Co., W.Va
Frenchtown Porcelain Co., NJ
Geuder, Paeschke & Frey Co., Wis
Heintz Mfg. Co., Pa
Independence Stove & Mfg. Co., Mo
Ingersoll Products Div., Borg-Warner Corp., Ill
Ingram-Richardson, Inc., Ind
Ingram-Richardson Mfg. Co., Pa
Kawneer Co., Mich
Lansdale Porcelain Enamel Corp., Pa
Metal & Thermit Corp., NJ
Metal-Cladding, Inc., NY
Monarch Aluminum Mfg. Co., Ohio
National Metal Products Co., Pa
Penn Fibre & Specialty Co., Inc., Pa
Philadelphia Enameling Works, Inc., Pa
Pittsburgh Plate Glass Co., Pa
Porcelain Enamel Finishers, Ill
Smith, A.O. Corp., Wis
Smoot-Holman Co., Calif
Southwestern Porcelain Steel Corp., Okla
Temco, Inc., Tenn
Vollrath Co., Wis

Inorganic Fibers

(except Asbestos, Ceramic, Glass, Carbon; see these categories)

Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Baldwin-Hill Co., NJ
Carborundum Co., NY
Carey, Philip Mfg. Co., Ohio
Electrofilm Inc., Calif
Gustin-Bacon Mfg. Co., Mo
Johns-Manville Corp., NY
L. O. F. Glass Fibers Co., Ohio
Modiglass Fibers, Inc., NJ
Standard Asbestos Mfg. Co., Ill
Thermal Refractories Corp., NJ
Union Carbide Metals Co., Div. of Union Carbide Corp., NY

Intermetallic Compounds

(see Ceramics; Refractories)

Investment Castings

(see castings)

Iron, Alloy

(castings)

Acme Foundry & Machine Co., Okla
Adirondack Steel Casting Co., NY
Advance Foundry Co., Ohio
Albion Malleable Iron Co., Mich
Alloy Precision Castings Co., Ohio
Almont Mfg. Co., Mich
Alten Foundry & Machine Works, Inc., Ohio
American Cast Iron Pipe Co., Ala
American Foundries Co., Mich
Apex Foundry, Inc., Mich
Apex Steel Corp., Ltd., Calif
Arzt, T.L. Foundry Co., Ill
Atlantic Foundry Co., Ohio
Banner Iron Works, Mo
Barber Iron Work, Inc., La
Bay City Foundry Co., Mich
Beaver Valley Alloy Foundry Co., Pa
Belle City Malleable Iron, Racine Steel Castings Co., Wis
Beloit Foundry Co., Ill
Bierman-Everett Foundry Co., NJ
Bignall Co., NY
Bonnot Co., Ohio
Brom Machine & Foundry Co., Minn
Butler Engine & Foundry Co., Inc., Pa
Cadillac Malleable Iron Co., Mich
Calumet Div., Calumet & Hecla, Inc., Mich
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Casting Service Corp. of Michigan Mich
Chambersburg Engineering Co., Pa
Chemung Foundry Corp., NY
Chicago Hardware Foundry Co., Ill
Cleveland Foundry & Mfg. Co., Inc., Tenn
Crawford & Doherty Foundry Co., Ore
Curtiss-Wright Corp., NY
Dalton Foundries, Inc., Ind
Dayton Foundry, Calif
Deuscher, H.P. Co., Ohio
Duriron Co., Inc., Ohio
Ehrsam, J.B. & Sons Mfg. Co., Kan
Electric Steel Foundry Co., Ore
Electron Corp., Colo
Elk Engineering Works, Inc., Pa
Engineered Castings Div., American Brake Shoe Co., NY
Enterprise Wheel & Car Corp., Va
Florence Pipe Foundry & Machine Co., NJ
Flynn & Emrich Co., Md
Frederick Iron & Steel, Inc., Md
G. & C. Foundry Co., Ohio
Gale Mfg. Co., Mich
General Electric Co., Foundry Dept., NY
Gillett & Eaton, Inc., Minn
Goslin Birmingham Mfg. Co., Inc., Ala
Grafton Foundry Co., Wis
Grede Foundries, Inc., Wis
Green Bay Foundry & Machine Works, Wis
Greenlee Foundry Co., Ill
Grimm Foundry Co., Inc., NJ
Gunite Foundries Corp., Ill
H & H Foundry Machine Co., Pa
Hamilton Foundry & Machine Co., Ohio
Helmick Foundry-Machine Co., W.Va
Hewitt, John Foundry Co., NJ
Howard Foundry Co., Ill
Irwin-Sensenich Corp., Pa
Janney Cylinder Co., Pa
Keen Foundry Co., Inc., Ind
Kingsport Foundry & Mfg. Corp., Tenn
Kolcast Industries Div., Thompson Products, Inc., Ohio
Kramer Bros. Foundry Co., Ohio
Kutztown Foundry & Machine Corp., Pa
Lake Erie Foundry Co., NY
Lang-Scharmann & Co., Wis
Lawton, C.A. Co., Wis
Liberty Foundry Co., Mo
Lincoln Foundry Corp., Calif
Littlestown Hardware & Foundry Co., Inc., Pa
Lodi Iron Works, Inc., Calif
Long Beach Iron Works, Calif
Macaulay, H.C. Foundry Co., Calif
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa
Manufacturers Iron Foundry, Inc., Conn
McLanahan & Stone Corp., Pa
Meehanite Metal Corp., NY
—Ad pp 378, 379
Mercast Mfg. Corp., Calif
Metropolitan Iron Foundry, NY
Midwestern Foundries, Inc., Ind
Montague Machine Co., Mass
National Iron Co., Minn
National Malleable & Steel Castings Co., Ohio
Neenah Foundry Co., Wis
North Wales Foundry Co., Inc., Pa
Oak Hill Foundry & Machine Works, Ohio
Oakland Foundry & Machine Co., Mich
Oil City Iron Works, Tex
Overmyer Mould Co., Inc., Ind
Parker-Street Castings Co., Ohio
Perkins, Henry Co., Mass
Pittsburgh Foundry & Machine Co., Pa
Pohlman Foundry Co., Inc., NY
Posey Iron Works, Inc., Pa
Potts, C. & G. & Co., Ind
Prescott Co., Mich
Pusey & Jones Corp., Del
Quaker Alloy Casting Co., Pa
Quest, J.F. Foundry Co., Minn
Republic Steel Corp., Ohio
Richmond Foundry & Mfg. Co., Inc., Va
Ridge Foundry, Calif
Riverside Foundry & Galvanizing Co., Mich
Rosedale Foundry & Machine Co., Pa
Ross-Meehan Foundries, Tenn
St. Marys Foundry Co., Ohio
Schaefer-Goodnow Foundries, Inc., Pa
Schneider, Bowman Co., Inc., Pa
Scudder, E.J. Foundry & Machine Co., NJ
Shakopee Foundry Co., Minn
Shartle Div., Black-Clawson Co., Ohio
Sheffield Foundry Co., Ill
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
Sibley Machine & Foundry Corp., Ind
Sioux City Foundry & Boiler Co., Iowa
Sonith Foundries, Food Machinery Corp., Ind
Sorbo-Mat Process Engineers, Mo
Sparta Foundry Div., Muskegon Piston Ring Co., Mich
Springfield Foundry Co., Mass
Spuck Iron & Foundry Co., Mo
Star Heel Plate Co., Inc., NJ
Stuart Foundry Co., Mich
Superior Foundry, Inc., Ohio
Taylor & Co., Inc., NY
Taylor & Boggis Foundry, Ohio
Taylor-Wharton Co., Div. of Harsco Corp., NJ
Texas Foundries, Inc., Tex
Tower Grove Foundry, Mo
Union Iron Works, Wash
United Shoe Machinery Corp., Mass
U.S. Pipe & Foundry Co., Ala
Uniworld Research Corp. of America, Ohio
Valley Iron Works, Minn
Wall Colmonoy Corp., Stainless Process Div., Mich
Washington Iron Works, Wash
Waterman Industries, Inc., Calif
West Point Foundry & Machine Co., Div. of Batson-Cook Co., Ga
Zenith Foundry Co., Wis

Iron, Gray

(castings)

ACF Industries, Inc., NY
Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Acme Foundry & Machine Co., Okla
Advance Foundry Co., Ohio
Albert Lea Foundry, Div. of Queen Products, Inc., Minn
Allegheny Foundry Co., Pa
Allis-Chalmers Mfg. Co., Wis
Alloy Precision Castings Co., Ohio
Almont Mfg. Co., Mich
Alten Foundry & Machine Works, Inc., Ohio
American Brake Shoe Co., NY
American Cast Iron Pipe Co., Ala
American Foundries Co., Mich
American Foundry Co., Inc., Ind
American Laundry Machinery Co., NY
Apex Foundry, Inc., Mich
Apex Steel Corp., Ltd., Calif
Appleton Electric Co., Ill
Arneson Foundry Co., Wis
Arzt, T.L. Foundry Co., Ill
Atlantic Foundry Co., Ohio
Atlas Foundry Co., Ohio
Atlas Foundry & Mfg. Co., Calif
Auburn Foundry, Inc., Ind
Avco Mfg. Corp., New Idea Div., NY
Banner Iron Works, Mo
Barber Iron Works Inc., La
Barnett Foundry & Machine Co., NJ
Bay City Foundry Co., Mich
Becker, L.A. Foundry Co., Mo
Bellaire Stove Co., Ohio
Belle City Malleable Iron, Racine Steel Castings Co., Wis
Beloit Foundry Co., Ill
Bethlehem Steel Co., Pa
Bierman-Everett Foundry Co., NJ
Bignall Co., NY
Black-Clawson Co., Ohio
Bond, Charles Co., Pa
Bonnot Co., Ohio
Brake Shoe & Castings Div., American Brake Shoe Co., NY
Bruce Foundry and Mfg. Co., Mich
Butler Engine & Foundry Co., Inc., Pa
Calumet Div., Calumet & Hecla, Inc., Mich
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Casting Service Corp. of Michigan, Mich
Central Specialty Div., King-Seeley Corp., Mich
Chambersburg Engineering Co., Pa.
Chemung Foundry Corp., NY
Chicago Hardware Foundry Co., Ill
Cincinnati Foundry Co., Ohio
Cleveland Foundry & Mfg. Co., Inc., Tenn
Columbiana Pump Co., Ohio
Compton Foundry, Calif
Continental Gin Co., Ala
Cooper-Bessemer Corp., Ohio
Crawford & Doherty Foundry Co., Ore
Dalton Foundries, Inc., Ind
Dana Corp., Auburn Div., Ind
Dayton Malleable Iron Co., Ohio
Decatur Casting Co., Ind
De Laval Steam Turbine Co., NJ
Detroit Brass & Malleable Co., Mich
Deuscher, H.P. Co., Ohio
Dexter Foundry Div., Philco Corp., Iowa
Dodge Mfg. Co., Ind
Dostal Foundry & Machine Co., Mich
Eaton Mfg. Co., Foundry Div., Mich
Ehrsam, J.B. & Sons Mfg. Co., Kan
Electron Corp., Colo
Elk Engineering Works, Inc., Pa
Elkhart Foundry & Machine Co., Inc., Ind
Elkhart Iron Works, Mich
Empire Pattern and Foundry Co., Okla
Engineered Castings Div., American Brake Shoe Co., NY
Enterprise Wheel & Car Corp., Va
Fearon Foundry Co., Ill
Florence Pipe Foundry & Machine Co., NJ
Florin Foundry & Mfg. Co., Pa
Flynn & Emrich Co., Md
Frederick Iron & Steel, Inc., Md
Fulton Foundry & Machine Co., Inc., Ohio
G. & C. Foundry Co., Ohio
Gale Mfg. Co., Mich
Gartland-Haswell Foundry, Inc., Ohio
General Electric Co., Foundry Dept., NY
General Foundry & Mfg. Co., Mich
General Iron Works Co., Colo
General Motors Corp., Central Foundry Div., Mich
Georgia Iron Works, Ga
Gillett & Eaton, Inc., Minn
Glamorgan Pipe & Foundry Co., Va
Globe Steel Abrasive Co., Ohio
Goslin-Birmingham Mfg. Co., Inc., Ala
Gowanda Furnaces, Inc., NY
Grafton Foundry Co., Wis
Grede Foundries, Inc., Wis
Green Bay Foundry & Machine Works, Wis
Greenlee Foundry Co., Ill
Grimm Foundry Co., Inc., NJ
Gunite Foundries Corp., Ill
H & H Foundry Machine Co., Pa
Hamilton Foundry & Machine Co., Ohio
Hardinge Mfg. Co., Pa
Headford Bros. & Hitchins Foundry Co., Iowa
Helmick Foundry-Machine Co., W.Va
Hewitt, John Foundry Co., NJ
Hodgson Foundry Co., Ill
Howard Foundry Co., Ill
Independence Stove & Mfg. Co., Mo
Industrial & Furnace Car Div., Irwin-Sensenich Corp., Pa
International Harvester Co., Ill
Janney Cylinder Co., Pa
Johnstone Foundries, Inc., Pa
Kanawha Mfg. Co., W.Va
Kansas City Hay Press Co., Mo
Katelman Foundry & Mfg. Co., Iowa
Keen Foundry Co., Inc., Ind
Kelly Foundry Co., Pa
Kingsport Foundry & Mfg. Corp., Tenn
Koehring Co., Wis
Kramer Bros. Foundry Co., Ohio
Kutztown Foundry & Machine Corp., Pa
Lake Erie Foundry Co., NY
Lakeside Malleable Casting Co., Wis
Lang-Scharmann & Co., Wis
Lawton, C.A. Co., Wis
Le Baron, E.L. Foundry, Mass
Lehigh, Inc., Pa
Letukas Foundry, Ind
Lewistown Foundry & Machine Co., Pa
Liberty Foundry Co., Mo
Lincoln Foundry Corp., Calif
Lincoln Iron Works, Vt
Link-Belt Co., Ind
Littie Foundries, Inc., Mich
Littlestown Hardware & Foundry Co., Inc., Pa
Lodge Mfg. Co., Tenn
Lodi Iron Works, Inc., Calif
Long Beach Iron Works, Calif
Macaulay, H.C. Foundry Co., Calif
Madison Foundry Co., Ohio
Magirl Foundry & Furnace Co., Ill
Manufacturers Iron Foundry, Inc., Conn
McCarter Iron Works, Inc., Pa
McLanahan & Stone Corp., Pa
Meehanite Metal Corp., NY
—Ad pp 378, 379
Mercast Mfg. Corp., Calif
Metropolitan Iron Foundry, NY
Midwestern Foundries, Inc., Ind
Milwaukee Malleable & Grey Iron Works, Wis
Montague Machine Co., Mass
Morrisville Foundry Co., Inc., Vt
National Grey Iron Foundry, Ill
National Iron Co., Minn
National Malleable & Steel Castings Co., Ohio
National Supply Co., Pa
Neenah Foundry Co., Wis
Noble & Wood Machine Co., NY
North Wales Foundry Co., Inc., Pa
Oak Hill Foundry & Machine Works, Ohio
Oakland Foundry & Machine Co., Mich
Oil City Iron Works, Tex
Overmyer Mould Co., Inc., Ind
Palmyra Foundry Co., Inc., NJ
Parker-Street Castings Co., Ohio
Pequonnock Foundry, Inc., Conn
Perkins, Henry Co., Mass
Pittsburgh Foundry & Machine Co., Pa
Pohlman Foundry Co., Inc., NY
Posey Iron Works, Inc., Pa
Potts, C. & G. & Co., Ind
Prescott Co., Mich
Pusey & Jones Corp., Del
Quest, J.F. Foundry Co., Minn
Refinery Castings Co., Tex
Republic Steel Corp., Ohio
Richmond Foundry & Mfg. Co., Inc., Va
Ridge Foundry, Calif
Riverside Foundry Co., Pa
Riverside Foundry & Galvanizing Co., Mich
Rodney Hunt Machine Co., Mass
Rosedale Foundry & Machine Co., Pa
Ross-Meehan Foundries, Tenn
St. Marys Foundry Co., Ohio
San Francisco Iron Foundry, Calif
Savannah Machine & Foundry Co., Foundry Div., Ga
Schaefer-Goodnow Foundries, Inc., Pa
Schneider, Bowman Co., Inc., Pa
Scudder, E.J. Foundry & Machine Co., NJ
Selma Foundry & Machine Co., Ala
Shakopee Foundry Co., Minn
Sharpsville Steel Fabricators, Inc., Pa
Shartle Div., Black-Clawson Co., Ohio
Sheffield Foundry Co., Ill
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
Sibley Machine & Foundry Corp., Ind
Sioux City Foundry & Boiler Co., Iowa
Somerset Foundry & Machine Co., Pa
Sonith Foundries, Food Machinery Corp., Ind
Sorbo-Mat Process Engineers, Mo
Southern Car & Mfg. Co., Inc., Ala
Sparta Foundry Div., Muskegon Piston Ring Co., Mich
Spencer's, I.S. Sons, Inc., Conn
Spring City Foundry Co., Pa
Springer's Foundry Co., Inc., Ind
Springfield Foundry Co., Mass
Spuck Iron & Foundry Co., Mo
Star Heel Plate Co., Inc., NJ
Stearns-Roger Mfg. Co., Colo
Sterling Foundry Co., Ill
Sterrit-Thomas Foundry Co., Pa
Stuart Foundry Co., Mich
Superior Foundry, Inc., Ohio
Swayne-Robinson & Co., Ind
Swett, A.L. Iron Works, NY
Taylor & Co., Inc., NY
Taylor & Boggis Foundry, Ohio
Terre Haute Malleable & Mfg. Corp., Ind
Texas Foundries, Inc., Tex
Tower Grove Foundry, Mo
Union Iron Works, Wash
United Shoe Machinery Corp., Mass
U.S. Pipe & Foundry Co., Ala
Utica General Jobbing Foundry, Inc., NY
Valley Iron Works, Minn
Vulcan Foundry Co., Calif
Vulcan Rail & Construction Co., NY
Washington Iron Works, Wash
Waterman Industries, Inc., Calif
Werner Foundry & Machine Co., Pa
West Point Foundry & Machine Co., Div. of Batson-Cook Co., Ga
Western Foundry & Machine Works, Inc., Kan
Western Iron & Foundry Co., Inc., Kan
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Wheland Co., Tenn
Wollaston Foundry Corp., Mass
Woodruff & Edwards, Inc., Ill
Yale & Towne Mfg. Co., Ill
Zellner Foundry Co., Ohio
Zenith Foundry Co., Wis

Iron, Ingot

Alan Wood Steel Co., Pa (o,w)
Alten Foundry & Machine Works, Inc., Ohio (o)
Armco Steel Corp., Ohio (o,q,z,bb,cc,dd)
Cannon-Muskegon Corp., Mich (w)
Crucible Steel Co. of America, Pa
(w)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,z,bb,cc,dd,ff)
Foote Mineral Co., Pa (aa)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Hayden Wire Works, Inc., Mass (o, bb,ee,ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
National Moldite Co., NY (aa)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Nesor Alloy Products Co., NJ (ff)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Ohio (w,aa)
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (o,ee)
Star Heel Plate Co., Inc., NJ (bb)
Superior Tube Co., Pa (ee)
Sylvania Electric Products, Inc., Parts Div., Pa (ff)

Iron, Malleable

(castings)

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Acme Steel & Malleable Iron Works, NY
Albion Malleable Iron Co., Mich
Alloy Precision Castings Co., Ohio
American Chain & Cable Co., Pa
American Malleable Castings Co., Ohio
American Steel and Wire Div., U.S. Steel Corp., Ohio
Appleton Electric Co., Ill
Auto Specialties Mfg. Co., Mich
Badger Malleable & Mfg. Co., Wis
Belle City Malleable Iron, Racine Steel Castings Co., Wis
Cadillac Mallable Iron Co., Mich
Chicago Malleable Castings Co., Ill
Connecticut Malleable Castings Co., Conn
Dana Corp., Auburn Div., Ind
Dayton Malleable Iron Co., Ohio
Detroit Brass & Malleable Co., Mich
Dodge Steel Co., Pa
Eastern Malleable Iron Co., Del
General Electric Co., Foundry Dept., NY
General Motors Corp., Central Foundry Div., Mich
Hodgson Foundry Co., Ill
Iowa Malleable Iron Co., Iowa
Jamestown Malleable Iron Corp., NY
Laconia Malleable Iron Co., NH
Lake City Malleable Co., Ohio
Lakeside Malleable Castings Co., Wis
Lancaster Malleable Castings Co., Pa
Lehigh, Inc., Pa
Lincoln Foundry Corp., Calif
Link-Belt Co., Ind
McCarter Iron Works, Inc., Pa
Meadville Malleable Iron Co., Pa
Meeker Foundry Co., NJ
Milwaukee Malleable & Grey Iron Works, Wis
Moline Iron Works, Ill
Muncie Malleable Foundry Co., Ind
National Malleable & Steel Castings Co., Ohio
Northern Malleable Iron Co., Minn
Pennsylvania Malleable Iron Corp., Pa
Prescott Co., Mich
Republic Steel Corp., Ohio
St. Louis Malleable Castings Co., Mo
Sharpsville Steel Fabricators, Inc., Pa
Sorbo-Mat Process Engineers, Mo
Star Heel Plate Co., Inc., NJ
Superior Steel & Malleable Castings Co., Mich
Terre Haute Malleable & Mfg. Corp., Ind
Texas Foundries Inc., Tex
United Shoe Machinery Corp., Mass
U.S. Challenge & Challenge Co., Ill
Vulcan Rail & Construction Co., NY
West Virginia Malleable Iron Co., W.Va
Westmoreland Malleable Iron Co., NY

Iron, Malleable Pearlitic

(castings)

Albion Malleable Iron Co., Mich
Auto Specialties Mfg. Co., Mich
Badger Malleable & Mfg. Co., Wis
Belle City Malleable Iron Co., Wis
Cadillac Mallable Iron Co., Mich
Canton Malleable Iron Co., Ohio
Chain Belt Co., Wis
Dalton Foundries, Inc., Ind
Dayton Malleable Iron Co., G.H.R. Div., Ohio
Eastern Malleable Iron Co., Del
Erie Malleable Iron Co., Pa
Federal Malleable Co., Wis
General Motors Corp., Central Foundry Div., Mich
I-F Mfg. Co., Ohio
Jamestown Malleable Iron Corp., NY
Laconia Malleable Iron Co., NH
Lakeside Malleable Casting Co., Wis
Lehigh Foundries Co., Div. of Lehigh Inc., Pa
Link-Belt Co., Ill
Meadville Malleable Iron Co., Pa
Milwaukee Malleable & Grey Iron Works, Wis
Moline Malleable Iron Co., Ill
National Malleable & Steel Castings Co., Ohio
Northern Malleable Iron Co., Minn
Peoria Malleable Casting Co., Ill
Pratt, William E. Mfg. Co., Ill
St. Louis Malleable Casting Co., Mo
Texas Foundries, Inc., Tex
Wagner Malleable Iron Co., Ill
Webster Mfg., Inc., Ohio

Iron, Nodular or Ductile

(castings)

Acme Foundry & Machine Co., Okla
Adirondack Steel Casting Co., NY
Advance Foundry Co., Ohio
Alloy Precision Castings Co., Ohio
Alten Foundry & Machine Works Inc., Ohio
American Cast Iron Pipe Co., Ala
Apex Foundry, Inc., Mich
Atlantic Foundry Co., Ohio
Bay City Foundry Co., Mich
Beloit Foundry Co., Ill
Black-Clawson Co., Ohio
Bonnot Co., Ohio
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Chambersburg Engineering Co., Pa
Chicago Hardware Foundry Co., Ill
Crawford & Doherty Foundry Co., Ore
Curtiss-Wright Corp., Metals Processing Div., NY
Dayton Foundry, Calif
Deuscher, H.P. Co., Ohio
Electron Corp., Colo
Engineered Castings Div., American Brake Shoe Co., NY
Goslin Birmingham Mfg. Co., Inc., Ala
Grede Foundries, Inc., Wis
Gunite Foundries Corp., Ill
Hamilton Foundry & Machine Co., Ohio
Hodgson Foundry Co., Ill
Howard Foundry Co., Ill
Jamestown Malleable Iron Corp., NY
Janney Cylinder Co., Pa
Kutztown Foundry & Machine Corp., Pa
Lincoln Foundry Corp., Calif
Meehanite Metal Corp., NY
—Ad pp 378, 379
Mercast Mfg. Corp., Calif
Montague Machine Co., Mass
Neenah Foundry Co., Wis
Rosedale Foundry & Machine Co., Pa
Ross-Meehan Foundries, Tenn
Sandy Hill Iron & Brass Works, NY
Savannah Machine & Foundry Co., Foundry Div., Ga
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
Sioux City Foundry & Boiler Co., Iowa
Southern Car & Mfg. Co., Inc., Ala
Taylor-Wharton Co., Div. of Harsco Corp., NJ
Texas Foundries, Inc., Tex
United Shoe Machinery Corp., Mass

Iron, Powders

Alan Wood Steel Co., Pa
Alloy Metal Powders, Inc., Iowa
Antara Chemicals Div., General Aniline & Film Corp., NY
Belmont Smelting & Refining Works, Inc., NY
Easton Metal Powder Co., Div. of American Mannex Corp., Pa
Ekstrand & Tholand, NY
Foote Mineral Co., Pa
Globe Steel Abrasive Co., Ohio
Hardy, Charles, Inc., NY
Hoeganaes Sponge Iron Corp., NJ
—Ad p 422
Johnson, A. & Co., Inc., NY
Magnetic Powders, Inc., Pa
National Moldite Co., NJ
National-U.S. Radiator Corp., Plastic Metals Div., NY
Norwalk Powdered Metals, Inc., Conn
Pyron Corp., NY
—Ad p 418
Republic Steel Corp., Ohio
—Ad pp 82-83
Shakopee Foundry Co., Minn
Sorbo-Mat Process Engineers, Mo
Steel Shot Producers, Inc., Pa
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Uniworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa

Iron, Wrought

Albert Pipe Supply Co., Inc., NY (ee)
American Silver Co., NY (v,dd)
Antara Chemicals Div., General Aniline & Film Corp., NY (aa)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Byers, A.M., Pa (o,q,z,ee)
Cannon-Muskegon Corp., Mich (w)
Dormont Mfg. Co., Pa (ee)
Gary Steel Products Corp., Va (o,z,bb)
Lockhart Iron & Steel Co., Pa (o,q)
National Electric Products Corp., Pa (ee)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Ohio
Sharpsville Steel Fabricators, Inc., Pa (z,dd)
Shaw-Kendall Engineering Co., Ohio (ee)
Titanium & Vacuum Metal Products Div., Crucible Steel Co. of America, Pa (o,q,z,bb,cc,dd,ff)
Vulcan Rail & Construction Co., NY (o,dd,ee)

Isocyanates

(see Urethanes)

Isoprene - Isobutylene Rubber

Adhesive Products Corp., NY (x)
Armstrong Cork Co., Pa (bb,cc,dd)
Atlas Mineral Products Co., Pa (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Brown Rubber Co., Inc., Ind (u)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Enjay Co., Inc., NY
—Ad p 247
Garlock Packing Co., NY (y,cc)
Geauga Industries Co., Ohio (y,bb,dd)
Goshen Rubber Co., Inc., Ind (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Insulation Mfrs. Corp., Ill (bb,cc,dd, ee)
Maloney, F.H. Co., Tex (y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y,cc,dd)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (x,y)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Polymer Chemical Co., Ohio (x)
Rand Rubber Co., NY (t,cc)
Raybestos - Manhattan, Inc., Plastic Products Div., Conn (x)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,ee)
Rogers Corp., Conn (cc,dd)
Roth Rubber Co., Ill (y,cc)
Sheller Mfg. Corp., Mich (u)
Standard Products Co., Mich (y)
Stockwell Rubber Co., Inc., Pa (y, cc,dd)
Technical Specialties Co., NY (dd)
Trostel, Albert Packing, Ltd., Wis (y)
U.S. Rubber Co., Kem-Blow Dept., Conn (u)
Vulcan Rubber Products Div., Reeves Bros. Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams - Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Lacquers

(see Organic Coatings)

Laminates

(see below; also Pre-Impregnated Materials)

Laminates, High Pressure, Plastics or Rubber

(sheet, rod or tube; incl. clad laminates)

Acme Specialties, Inc., Pa (k,l,m)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Brakeblok Div., American Brake Shoe Co., Mich (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Auburn Plastic Engineering, Ill (k)
Baer, N.S. Co., NJ (l)

Cadillac Plastic & Chemical Co., Mich (l)
Calfibe Co., Inc., Calif (l)
Castle Rubber Co., Pa (m)
Coating Products, Inc., NJ (l)
Colonial Art Co., Inc., Mass (k)
Conneaut Rubber and Plastics Co., Div. of U.S. Stoneware Co., Ohio (k,l,m)
Connecticut Hard Rubber Co., Conn (m)
Conolite Div., Continental Can Co., Del (l)
Consoweld Corp., Wis (l)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Curbell, Inc., NY (l)
Davidson Rubber Co., Mass (m)
Davis, Joseph Plastics Co., NJ (k)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (m)
Dumont Corp., Calif (k,l,m)—Ad p 410
Electro Chemical Engineering & Mfg. Co., Pa (k,m)
Everlite Corp., Wash (l)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Farley & Loetscher Mfg. Co., Iowa (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Gatke Corp., Ill (l)
General Electric Co., Laminated Products Dept., Ohio (l)—Ad p 244
General Plastics Corp., Ind (k)
General Plastics Corp., NJ (k,l)
General Tire & Rubber Co., Ind (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
H & R Industries, Pa (k)
Halogen Insulator & Seal Corp., Ill (l)
Hartwell, H.N. & Son, Inc., Mass (k)
Haskelite Mfg. Corp., Mich (l)
Haveg Industries, Inc., Del (l)
Home Rubber Co., NJ (m)
Insulation Mfrs. Corp., Ill (k)
Iten Fibre Co., Ohio (l)
Johns-Manville Corp., NY (k,l)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (k)
Kerr, R.W. Plastic Co., Neb (k,l)
Lewis, J.P. Co., Plastic Products Div., NY (l)
Luminous Resins, Inc., Ill (k)
Maloney, F.H. Co., Tex (l)
Marblette Corp., NY (l)
Mechanical Rubber Products Co., NY (l)
Mica Corp., Calif (l)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Moxness Products, Inc., Wis (l,m)
National Vulcanized Fibre Co., Del (l)—Ad p 226
New England Laminates Co., Inc., Conn (l)—Ad p 122
Northern Plastics Corp., Wis (l)
Panelyte Div., St. Regis Paper Co., NY (l)
Penn Fibre & Specialty Co., Inc., Pa (l)
Philrus Products Co., NJ (k,l)
Porter, William Co., Calif (l)
Prince Rubber Co., Inc., NY (k)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Ren Plastics, Inc., Mich (l)
Replac Corp., Ohio (k,l,m)
Richardson Co., NY (l)
Reflin Co., Calif (l)
Rogers Corp., Conn (l)
Ryerson, Joseph T. & Son, Inc., Ill (l)
Seiberling Rubber Co., Plastics Div., Ohio (k,m)
Shamban, W.S. & Co., Ind (k)
Sillcocks Miller Co., NJ (k)
Spaulding Fibre Co., Inc., NY (l)—Ad p 251
Standard Insulation Co., NJ (l)
Sun Steel Co., Ill (k)
Swedlow, Inc., Calif (k,l)
Synthane Corp., Pa (l)
Taylor Fibre Co., Pa (l)—Ad p 227
Thermoid Div., H.K. Porter Co., Pa (k,m)
Thombert, Inc., Iowa (l)
U. S. Gasket Plastics Div., Garlock Packing Co., NJ (k)
U.S. Polymeric Chemicals, Inc., Conn (k)
Vulcan Rubber Products Div., Reeves Bros. Inc., NY (m)
Vulcanized Rubber & Plastics Co., Pa (m)
Westlake Plastics Co., Pa (l)

Laminates, Low Pressure, Plastics or Rubber

(sheet, rod or tube; incl. clad laminates)

Acme Specialties, Inc., Pa (k,l,m)
Allegheny Plastics, Inc., Pa (k)
Allied Resinous Products, Inc., Ohio (k)
Alsynite Co. of America, Calif (l)
American Agile Corp., Ohio (k)
American Insulator Corp., Pa (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (m)
Auburn Plastic Engineering, Ill (l)
Baer, N.S. Co., NJ (l)
Biggs, Carl H. Co., Inc., Calif (l)
Blank, Arthur & Co., Inc., Mass (k)
Cadillac Plastic & Chemical Co., Mich (k,l)
Calfibe Co., Inc., Calif (l)
Carroll, J.B. Co., Ill (k)
Castle Rubber Co., Pa (m)
Clad-Rex Corp., Ill (k)
Coating Products, Inc., NJ (l)
Connecticut Hard Rubber Co., Conn (m)
Consolidated Molded Products Corp., Pa (l)
Continental Can Co., NY (l)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Corite Products Inc., Ill (l)
Corrulux Div., L.O.F. Glass Fibers Co., Tex (l)
Dumont Corp., Calif (k,l,m)—Ad p 410
Dura Plastics of New York, Inc., NY (k)
Eljay Corp., Md (k,l)
Emerson & Cuming, Inc., Mass (k,l,m)
Everlite Corp., Wash (l)
Fiber Glass Industries, Inc., NY (l)
Fiberglass Ohio Inc., Ohio (l)
Filon Plastics Corp., Calif (l)
Foss Mfg. Co., Plastics Div., Id (l)
Frost Rubber Co., Ill (m)
Fry Plastics Co., Calif (k)
Gering Products, Inc., NJ (k)
Glastic Corp., Ohio (l)—Ad p 290
Goodrich, B.F. Industrial Products Co., Ohio (k)
Haskelite Mfg. Corp., Mich (l)
Haveg Industries, Inc., Del (l)
Hays Mfg. Co., Pa (l)
Heil Process Equipment Corp., Ohio (l)
Home Rubber Co., NJ (m)
Insulation Mfrs. Corp., Ill (k)
Kaykor Industries, Inc., NJ (k)
Kerr, R.W. Plastic Co., Neb (k,l)
Koch, H. & Sons, Calif (l)
Laminated Plas-Tex Corp., Ohio (k)
Lamtex Industries, Inc., NY (l)
Lun Laminates, Inc., NY (l)
Mechanical Rubber Products Co., NY (l)
Mica Corp., Calif (l)
Mica Insulator Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Minnesota Mining & Mfg. Co., Reinforced Plastics Div., Minn (l)
National Vulcanized Fibre Co., Del (l)—Ad p 226
New England Laminates Co., Inc., Conn. (l)—Ad p 260
Penn Fibre & Specialty Co., Inc., Pa (l)
Perry Plastics Inc., Pa (k,l)
Philrus Products Co., NJ (k,l)
Porter, William Co., Calif (l)
Precision Paper Tube Co., Ill (l)
Rand Rubber Co., NY (k,l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Reflin Co., Calif (l)
Ren Plastic, Inc., Mich (l)
Replac Corp., Ohio (l,m)
Resolite Corp., Pa (l)
Rowland Products, Inc., Conn (k)
Rubatex Div., Great American Industries, Inc., Va (u)
Rubber Corp. of America, NY (k)
Russell Reinforced Plastics Corp., NY (l)
Schori Process Div., Ferro-Co Corp., NY (l)
Scranton Plastic Laminating Corp., Pa (k)
Sealview Plastics, Inc., Pa (l)
Sewell Mfg. Co., Mich (k)
Shamban, W.S. & Co., Ind (k)
Sierra Electric Corp., Calif (l)
Sillcocks Miller Co., NJ (k)
Southern Plastics Co., SC (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Standard Insulation Co., NJ (l)
Stockwell Rubber Co., Inc., Pa (k,m)
Stone Paper Tube Co., Washington, DC (k)
Strick Plastics Co., Pa (m,k,l)
Swedlow, Inc., Calif (k,l)
U.S. Polymeric Chemicals, Inc., Conn (k)
U.S. Rubber Co., NY (k)
Urrite Plastics Fabricators, Calif (k)
Vulcan Rubber Products Div., Reeves Bros. Inc., NY (m)
Vulcanized Rubber & Plastics Co., Pa (m)
Westlake Plastics Co., Pa (l)
Woodall Industries, Inc., Mich (k,l)
Youngstown Sheet & Tube Co., Ohio (l)
Zenith Plastics Co., Sub. of Minnesota Mining & Mfg. Co., Calif (l)

Laminates, High or Low Pressure, Plastics or Rubber—Moldings

(incl. clad laminates)

Admiral Corp., Molded Products Div., Ill (l)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Brakeblok Div., American Brake Shoe Co., Mich (k)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Arrowhead Products, Calif (l,m)
Artmor Plastics Corp., Md (l)
Baer, N.S. Co., NJ (l)
Bassons Industries, Corp., NY (l)
Brunswick-Balke-Collender Co., Defense Products Div., Mich (l)
Byers, A.M. Co., Pa (k)
Cadillac Plastic & Chemical Co., Mich (k,l)
Calfibe Co., Inc., Calif (l)
Camfield Fiberglass Plastics, Inc., Mich (l)
Carroll, J.B. Co., Ill (k)
Castle Rubber Co., Pa (m)
Colonial Art Co., Inc., Mass (k)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (k,m)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Corite Products, Inc., Ill (l)
Curtiss-Wright Corp., Utica Div., Mich (l)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Dumont Corp., Calif
(k,l,m)—Ad p 410
Eljay Corp., Md (l)
Englander Co., Inc., Industrial Products Div., Md (l)
Fiber Glass Industries, Inc., NY (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Foss Mfg. Co., Plastics Div., Id (l)
Frost Rubber Co., Ill (m)
Fry Plastics Co., Calif (l)
Galigher Co., Utah (k)
Gatke Corp., Ill (l)
General American Transportation Corp., Ill (l)
General Electric Co., Plastics Dept., Ill (l)
General Electric Co., Laminated Products Dept., Ohio
(l)—Ad p 244
General Tire & Rubber Co., Ind (k)
Gering Products, Inc., NJ (k)
Glass Reinforced Plastics Corp., Ohio (l)
Glastic Corp., Ohio
(l)—Ad p 290
H & R Industries, Pa (k)
Haskelite Mfg. Corp., Mich (l)
Haveg Industries, Inc., Del (l)
Hawley Products Co., Ill (l)
Hays Mfg. Co., Pa (l)
Hewitt-Robins, Inc., Conn (m)
Home Rubber Co., NJ (m)
Insulation Mfrs. Corp., Ill (k)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (k)
Kerr, R.W. Plastic Co., Neb (k,l)
Knight, Maurice A., Ohio (l)
Lamtex Industries, Inc., NY (l)
Lone Star Plastics Co., Inc., Tex (l)
Lunn Laminates, Inc., NY (k,l)
Maloney, F.H. Co., Tex (l)
Mechanical Rubber Products Co., NY (l)
Mica Corp., Calif (l)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Minnesota Mining & Mfg. Co., Reinforced Plastics Div., Minn (l)
Molded Fiber Glass Co., Ohio (l)
National Vulcanized Fibre Co., Del
(l)—Ad p 226
New England Laminates Co., Inc., Conn
(l)—Ad p 260
Northwest Plastics Industries, Inc., Minn (l)
Panelyte Div., St. Regis Paper Co., NY (l)
Penn Fibre & Specialty Co., Inc., Pa (k)
Plymouth Industrial Products, Inc., Wis (k)
Porter, William Co., Calif (l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Ren Plastic, Inc., Mich (l)
Replac Corp., Ohio (k,l,m)
Resolite Corp., Pa (l)
Richardson Co., Ill (l)
Riverside Plastics Corp., NY (l)
Russell Reinforced Plastics Corp., NY (l)
Shamban, W.S. & Co., Ind (k)
Sierra Electric Corp., Calif (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Spaulding Fibre Co., Inc., NY
(l)—Ad p 251
Standard Insulation Co., NJ (l)
Stockwell Rubber Co., Inc., Pa (k,m)
Strick Plastics Co., Pa (k,l,m)
Structural Fibers, Inc., Ohio
(l)—Ad p 398
Sun Rubber Co., Ohio (m)
Swedlow, Inc., Calif (k,l)
Synthane Corp., Pa (l)
Taylor Fibre Co., Pa
(l)—Ad p 227
Thermoid Div., H.K. Porter Co., Pa (l)
Thompson, H.I. Fiber Glass Co., Calif
(k)—Ad p 263
Toledo Industrial Rubber Co., (l)
U.S. Polymeric Chemicals, Inc., Conn (k)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (m)
Warminster Fibreglas Co., Div. of Fischer & Porter Co., Pa (l)
Waterbury Cos., Inc., Conn (l)
Winner Mfg. Co., Inc., NJ (l)
Wittman, Lawrence & Co., NY (l)
Woodall Industries, Inc., Mich (k,l)
Zenith Plastics Co., Sub. of Minnesota Mining & Mfg. Co., Calif (l)

Laminates, Metal-Metal

(incl. "bimetals"; key letters refer to base metal)

Al-Fin Div., Fairchild Engine & Airplane Corp., NY (a,e)
Almco Steel Products Corp., Ind (g)
American Cast Iron Pipe Co., Ala
(c,g)
American Silver Co., Inc., NY (b,c,f,g)
Baker & Co., Inc., NJ (b,f)
Brunswick-Balke-Collender Co., Defense Products Div., Mich (a)
Chace, W.M. Co., Mich (a,b,c,e,f,g,h,j)
Copperweld Steel Co., Ohio (g)
Eastern Brass & Copper Co., NY (a)
Eastern Smelting & Refining Corp., Mass (b)
Gar Precision Parts, Inc., Conn (b,f)
General Finding & Supply Co., Industrial Div., Mass (b,f)
General Plate Div., Metals & Controls Corp., Mass (a,b,c,e,f,g,h,j)
Improved Seamless Wire Co., RI (b,c,f)
Knapp Mills, Inc., NY (b,g)
Laminated Shim Co., Conn (a,b,g)
Leach & Garner Co., Industrial Div., Mass (b,f)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (b,c,f,g)
Mechanical Steel Tubing Corp., NY (a,g)
Nuclear Metals, Inc., Mass (a,b,c,e,f,g,h)
Presswork, Inc., Mich (b,d)
Revere Copper & Brass, Inc., Foil Div., NY (a)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Standard Metals Corp., Mass (a,b,c,f,g)
Staver Co., Inc., NY (a,b)
Sylvania Electric Products, Inc., NY (b,f)
Wilson, H.A. Co., Div. of Engelhard Industries, Inc., NJ
(b,f,g)—Ad p 34
Wisconsin Gasket & Mfg. Co., Ohio (b,g)

Laminates, Metal-Organic

(key letters refer to base metal)

American Nickeloid Co., Ill (a,g)
Arvin Industries, Inc., Ind (a,e,g)
Benjamin Electric Mfg. Co., Ill (g)
Clad-Rex Corp., Ill
(a,g)—Ad p 335
Coated Coil Corp., NY (a,g)
Cochran Foil Co., Ky (a)
Dumont Corp., Calif
(a)
Enamel Products Co., Ohio (a,c)
Enamelstrip Corp., Sub. of National Steel Corp., Pa (a,b,c,f,g,j)
Gomar Mfg. Co., Inc., NJ (a)
Hood Rubber Co., Div. of B.F. Goodrich Chemical Co., Mass (a,g)
Kaiser Aluminum & Chemical Sales Inc., Ill (a)
Maloney, F.H. Co., Tex (g)
Mechanical Steel Tubing Corp., NY (a,g)
Met-L-Wood Corp., Ill
(a,b,d,f,g)
O'Sullivan Rubber Corp., Va (a,b,e,g)
Sun Steel Co., Ill (a,e,g)
Young, M.M. Div., Litho-Strip Corp., Ill (a,g)

Laminates, Wood-Metal

Haskelite Mfg. Corp., Mich
Keller Products, Inc., NH
Laminated Veneers Co., NY
Met-L-Wood Corp., Ill
—Ad p 32
Technical Ply-Woods Sales, Ill
U.S. Plywood Corp., NY

Laminating Resins

(see specific plastic or rubber)

Lead and Its Alloys

A & A Die Casting Co., Calif (q)
Advance Stamping Co., Mich (dd)
Alpha Metals, Inc., NJ (n,o,v,w,z,aa,bb,cc,dd)
American Metal Climax, Inc., NY (n,o,w,aa,bb)
American Nickel Alloy Mfg. Corp., NY (w)
American Smelting & Refining Co., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Bar-Ray Products, NY (v,z,cc)
Bearium Metals Corp., NY (w)
Belmont Smelting & Refining Works, Inc., NY
(n,o,v,w,z,aa,cc,ff)—Ad p 159
Bunker Hill Co., Calif (n,o,w,z,bb,cc,dd,ee,ff)
Cerro de Pasco Sales Corp., NY
(w)—Ad p 154
Chicago Smelting & Refining Corp., Ill (w)
Crown Metal Co., Wis (n,o,q,w,bb,cc,dd,ee,ff)
Designers Metal Corp., Ill (cc)
Dietzel Lead Burning Co., Pa (n,o,z,cc)
Division Lead Co., Ill (n,o,v,w,z,aa,cc,dd,ee,ff)
Dixie Lead Co., Tex (n,o,q,w,aa,cc)
Eagle-Picher Co., Ohio (aa)
Empire Metal Co., NY (n,o,q,v,w,z,bb,cc,dd,ee,ff)
Evans Metal Co., Ga (w,cc,ee)
Federated Metals Div., American Smelting & Refining Co., NY (n,o,w,cc,ee,ff)
Fox Products Co., Pa (n)
General Plate Div., Metals & Controls Corp., Mass (dd)
Glidden Co., Ind (aa)
Glidden Co., Chemicals-Pigments-Metals Div., Md
(aa)—Ad p 391
Goldsmith Bros. Smelting & Refining Co., Ill (o,q,w)
Greenback Industries, Inc., Mich (aa)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hayman, Michael & Co., NY (o,w)
Heil Process Equipment Corp., Ohio (n)
Hi-Grade Alloy Corp., Ill (n,o,v,w,z,bb,cc,ee,ff)
Indium Corp. of America, NY
(v,cc,dd,ff)
Johnston Foil Div., Standard Packaging Corp., Mo (v,cc)
Kinkead Industries, Inc., Ill (cc,dd)
Kirk, Morris P. & Son, Calif (n,o,q,w,z,aa,bb,cc,dd)
Lavin, R. & Sons, Inc., Ill (n,w)
McGean Chemical Co., Ohio (n,o,aa,bb,dd)
Metal & Thermit Corp., NJ (n)
Metallizing Co. of Los Angeles, Inc., (ff)
Metals Disintegrating Co., Inc., NJ
(aa)—Ad p 415
National Lead Co., NY (n,o,q,w,z,aa,bb,cc,dd,ee,ff)
National Lead Construction Co., Inc., NJ (n,o,w,z,cc,ee,ff)
Nesor Alloy Products Co., NJ (ff)
New England Smelting Works, Inc., Mass (o,w)
Oatey, L.R. Co., Ohio (o,w,cc,dd)
Olds Alloy Co., Calif (q,w)
Peerless Alloy Co., Colo (n,o,q,w,z,bb,cc)
Peerless Roll Leaf Co., Inc., NJ (v,dd)
Pittsburgh Smelting & Refining Co., Pa (o,w,cc)
Presswork, Inc., Mich (o,cc)
Republic Lead Equipment Co., Ohio (n)
Republic Metals Co., Inc., NY (n,o,q,v,w,z,cc,ee,ff)
Revere Copper & Brass, Inc., Foil Div., NY (v)
River Smelting & Refining Co., Ohio (o,w)
Rotometals, Calif (o,w,bb,cc,dd,ee,ff)
St. Joseph Lead Co., NY (w)
Sall, George Metals Co., Inc., Pa (w)
Staver Co., Inc., NY (v,cc,dd)
Stevens, Frederic B., Inc., Mich (n)
Udylite Corp., Mich (n)
U.S. Smelting, Refining & Mining Co., NY (w)
U.S. Stoneware Co., Ohio (n)
Waltham Foundry Co., Mass (w)

Leather and Leather Parts

Alexander Bros. Belting Co., NJ
Alexander, E.P. & Son, Pa
Auburn Mfg. Co., Conn
—Ad p 420
Bond, Charles Co., Pa
Charlotte Leather Belting Co., NC
Chicago Rawhide Mfg. Co., Ill
Chicago-Allis Mfg. Corp., Ill
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill
Donovan, F.C., Inc., Mass
Excelsior Leather Washer Mfg. Co., Inc., Ill
Foss Mfg. Co., Plastics Div., Id
Garlock Packing Co., NY
General Gasket, Inc., Conn
Gibb, Walton Leather Co., Pa
Glenn, Joseph & Sons, Inc., Pa
Graton & Knight Co., Mass
Haffner Bros. Co., Ohio
Hay, James E. Co., Inc., Mass
Houghton, E.F. & Co., Pa
International Packings Corp., NH
—Ad p 423
Mechanical Leathers, Inc., Pa
Michigan Leather Products Co., Mich
National Gasket & Washer Mfg. Co., Inc., NY
Norwich Leather Co., Conn
Page Belting Co., NH
Penn Fibre & Specialty Co., Inc., Pa
Porter, William Co., Calif
Rhoads, J.E. & Sons, Del
Schachner Leather & Belting Co., Charlotte Leather Belting Co. Div., NC
Shingle Leather Co., NJ
Sillcocks Miller Co., NJ
Southern Belting & Transmission Co., Ga

Standard Washer & Mat, Inc., Conn
Staver Co., Inc., NY
Truche Leather Co., Mass
Warren Belting Co., Mass
Winworth Co., Inc., NJ

Lignum Vitae

(see Wood)

Lithium

American Potash & Chemical Corp., Calif (w)
Belmont Smelting & Refining Works, Inc., NY (o,aa)
Foote Mineral Co., Pa (w)
Hardy, Charles, Inc., NY (aa)
Lithium Corp. of America, Inc., Minn (w,bb,ff)—Ad p 147
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)

Low Pressure Laminates

(see Laminates)

Magnesium and Its Alloys

Aluminium Ltd. Sales, Inc., NY (w)
Aluminum Co. of America, Pa (n,o,q,z,bb,cc,dd)
Aluminum & Magnesium, Inc., Ohio (w)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,w)
Apex Smelting Co., Ill (n,w)
Arcos Corp., Pa (ff)
Armet Alloys, Inc., Ohio (n,w)
Belmont Smelting & Refining Works, Inc., NY (w)—Ad p 159
Brooks & Perkins, Inc., Mich (z,cc,dd)—Ad p 410
Copper & Brass Sales, Inc., Mich (o,z,bb,cc,dd,ee,ff)
Dahlin, C.A. Co., Ill (cc)
Designers Metal Corp., Ill (cc)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (n,o,q,w,z,aa,bb,cc,dd,ee,ff)
Federated Metals Div., American Smelting & Refining Co., NY (n,w)
Hardy, Charles, Inc., NY (aa)
King Laboratories, Inc., NY (w,aa)
Kinkead Industries, Inc., Ill (cc,dd)
Light Metals, Inc., Ind (n)
Magline, Inc., Mich (o,z,bb,cc,ee,ff)
Magna Mfg. Co., Inc., NJ (aa)
Magnesium Elektron, Inc., NY (n,w)
Magnode Products, Inc., Ohio (n,o,bb,dd,ee)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,ee)
McGean Chemical Co., Ohio (aa)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Norrich Plastics Corp., NY (o,bb)
Nuclear Metals, Inc., Mass (bb,dd,ee)
Peerless Roll Leaf Co., Inc., NJ (v,dd)
Reade Mfg. Co., Inc., NJ (aa)
Standard Magnesium Corp., Okla (n,q,w)
Tube Distributors Co., Inc., NY (ee)
Ullmann, Inc., Wis (o,ee)
U.S. Magnesium Co., NY (aa)
Utical General Jobbing Foundry, Inc., NY (o)
Vanadium Corp. of America, NY (w)
Waltham Foundry Co., Mass (w)
White Metal Rolling & Stamping Corp., NY (n,o,q,z,bb,cc,dd,ee,ff)—Ad p 418

Manganese and Its Alloys

Amalgamated Steel Corp., Ohio (o,bb)
American Nickel Alloy Mfg. Corp., NY (w)
Anaconda Co., NY (n,v,cc)
Belmont Smelting & Refining Works, Inc., NY (w,aa)
Chicago Development Corp., Md (o,v,z,bb,cc,dd,ee,ff)
Dahlin, C.A. Co., Ill (cc)
Foote Mineral Co., Pa (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Hommel, O. Co., Pa (aa)
Lavin, R. & Sons, Inc., Ill (w)
Metals Disintegrating Co., Inc., NJ (aa)—Ad p 415
National Paint & Manganese Co., Va (aa)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
New Jersey Zinc Co., NY (w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Pioneer Aluminum, Inc., Calif (z)
Taylor-Wharton Co., Div. of Harsco Corp., NJ (z,bb,ff)
Tube Distributors Co., Inc., NY (ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Utica General Jobbing Foundry, Inc., NY (aa)
Vanadium Corp. of America, NY (w)

Manganese Bronze

(see Copper)

Mechanical Fasteners

Abalon Precision Mfg. Corp., NY
Acme Machine Products Div., Serrick Corp., Ind
Acme Stamping & Mfg. Co., Pa
Albany Products Co., Inc., Conn
Allmetal Screw Products Co., Inc., NY
Aluminum Co. of America, Pa
American Screw Co., Conn
American Steel and Wire Div., U.S. Steel Corp., Ohio
Anti-Corrosive Metal Products Co., Inc., NY
Atlantic Steel Co., Ga
Automatic Nut Co., Pa
Automotive Rubber Co., Inc., Mich
Aviation Developments, Inc., Calif
Bethlehem Steel Co., Pa
Blake & Johnson Co., Conn
Boots Aircraft Nut Corp., Conn
Bostitch, Inc., RI
Buffalo Bolt Div., Buffalo-Eclipse Corp., NY
C. E. M. Co., Conn
Camloc Fastener Corp., NJ
Central Screw Co., Ill
Champion Rivet Co., Ohio
Chicago Rivet & Machine Co., Ill
Chicago Screw Co., Div. of Standard Screw Co., Ill
Cleveland Cap Screw Co., Ohio
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif.
Consolidated Fruit Jar Co., NJ
Continental Screw Co., Mass
Dimco-Gray Co., Ohio
Driv-Lok Sales Corp., Ill
Elastic Stop Nut Corp. of America, NJ
Electric Steel Foundry Co., Ore
Erie Bolt & Nut Co., Pa
Falstrom Co., NJ
Fastex Div., Illinois Tool Works, Ill
Gries Reproducer Corp., NY —Ad p 460
Grip Nut Co., Ind —Ad p 460
Groov-Pin Corp., NJ
Hartford Machine Screw Co., Div. of Standard Screw Co., Conn
Hassall, John, Inc., NY
Heli-Coil Corp., Conn
Hi-Shear Rivet Tool Co., Calif
Holo-Krome Screw Corp., Conn
Huck Mfg. Co., Mich
Ideal Can Co., Mass
Jaques Co., Mass
K S M Products, Inc., NJ
Kinkead Industries, Inc., Ill
Klincher Locknut Corp., Ind
Langsenkamp, F.H. Co., Ind
Lincoln Iron Works, Vt
Lundquist Tool & Mfg. Co., Inc., Mass
MacLean-Fogg Lock Nut Co., Ill
Magnesium Co. of America, Ind
Magnesium Products of Milwaukee, Inc., Wis
Metal Goods Corp., Mo
Miracle Adhesives Corp., NY
National Lock Co., Fastener Div., Ill
National Machine Products Co., Mich
Nelson Stud Welding Div., Gregory Industries, Inc., Ohio
Nutt-Shel Co., Calif
Nylok-Detroit, Mich
Ohio Nut & Bolt Co., Ohio
Palnut Co., NJ
Parker-Kalon Div., General American Transportation Corp., NJ
Penn Engineering & Mfg. Corp., Pa
Plastiglide Mfg. Corp., Calif
Plume & Atwood Mfg. Co., Conn
Prestole Corp, Ohio
Red Devil Mfg. Co., Ill
Reynolds Aluminum Supply Co., Ga
Rhode Island Tool Co., RI
Rolled Alloys, Inc., Mich
Russell, Burdsall & Ward Bolt & Nut Co., NY
Set Screw & Mfg. Co., Ill —Ad p 456
Shakeproof Div., Illinois Tool Works, Ill
Sharon Steel Corp., Pa
Shur-Lok Corp., Calif
Sillcocks Miller Co., NJ
Simmons Fastener Corp., NY —Ad p 455
Simonsen Metal Products Co., Ill
Snyder Mfg. Co., Inc., Ohio
Southco Div., South Chester Corp., Pa
Southern Screw Co., NC
Special Screw Products Co., Ohio
Standard Locknut & Lockwasher, Inc., Ind
Standard Pressed Steel Co., Pa
Star Expansion Industries Corp., NY
Star Stainless Screw Co., NJ
Sterling Bolt Co., Ill
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala
Thompson-Bremer & Co., Ill
Thomson, Judson L. Mfg. Co., Mass
Tinnerman Products, Inc., Ohio
Torrington Co., Conn
Torrington Co., Specialties Div., Conn
Townsend Co., Fasteners Div. Pa
Tubular Rivet & Stud Co., Mass
United Shoe Machinery Corp., Mass
United-Carr Fastener Corp., Mass
Waldes Kohinoor, Inc., NY
Waterbury Pressed Metal Co., Conn
Waterman Industries, Inc., Calif
Weckesser Co., Ill
Wesbar Stamping Corp., Wis
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio
Whitehead Metal Products Co., Inc., NY
Wilson, H.A. Div., Engelhard Industries, Inc. NJ
Worth Co., Wis

Melamines

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p,y)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,y)
American Cyanamid Co., Plastics & Resins Div., NY (p,x,y)—Ad pp 231-232
Baer, N.S. Co., NJ (bb,cc,dd,ee)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Catalin Corp. of America, NY (p,x)
Colonial Kolonite Co., Ill (bb,cc,ee)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,dd,ee)
Dapol Plastics, Inc., Mass (y)

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x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Dyna-Therm Chemical Corp., Calif (p)
Farley & Loetscher Mfg. Co., Plastics Div., Iowa (cc)
Fiberite Corp., Minn (y)—Ad p 259
Fluoro-Plastics, Inc., Div. of Flexrock Co., Pa (bb,cc)
Formica Corp., Sub. of American Cyanamid Co., Ohio (bb,cc,ee)
General Electric Co., Laminated Products Dept., Ohio (bb,cc,ee)
Grigoleit Co., Ill (p,s)
Haskelite Mfg. Corp., Mich (cc,dd)
Iten Fibre Co., Ohio (bb,cc,dd,ee)
Kurz Kasch, Inc., Ohio (y)
Laminated Plastex Corp., Ohio (x,cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc)
Monsanto Chemical Co., Plastics Div., Mass (p,x)
Muehlstein, H. & Co., Inc., NY (p,y)
National Vulcanized Fibre Co., Del (bb,cc,dd,ee)
Northern Plastics Corp., Wis (cc,dd)
Omni Products Corp., NY (y)
Panelyte Div., St. Regis Paper Co., NY (x,bb,cc,dd,ee)
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Reichhold Chemical, Inc., NY (p,x)
Richardson Co., NY (bb,cc,ee)
Robot Devices, Inc., Va (u)
Spaulding Fibre Co., Inc., NY (bb,cc,dd,ee)
Synthane Corp., Pa (bb,cc,dd,ee)
Taylor Fibre Co., Pa (bb,cc,dd,ee)
Texas Glass Fiber Corp., Tex (y)
U.S. Polymeric Chemical, Inc., Conn (s)
Westlake Plastics Co., Pa (bb,cc,dd,ee)

Metal Powder Parts

(Metal Compacts)

Allied Products Corp., Mich (c)
Aluminum Co. of America, Pa (a)
American Brake Shoe Co., NY (a,b,c,f,g,)
American Nickel Alloy Mfg. Corp., NY (f)
American Powdered Metals, Inc., Conn (b,c,f)
American Sinteel Corp., NY (b,c,d,g)
American Sinterings Div., Engineered Plastics, Inc., Conn (b,c,f,g,j)
Amplex Div., Chrysler Corp., Mich (b,c,f,g)—Ad p 389
Arnold Engineering Co., Ill (c,f)
Arrow Sintered Products Co., Ill (b,c,g)
Asco Sintering Corp., Calif (a,b,c,d,f,g)
Atlas Brass Foundry, Calif (b,c)
Bassick Co., Conn (a,b,c,f,g)
Bendix Aviation Corp., NJ (a,b,c,f,g)
Boston Gear Works, Mass (a,b,c,f,g)
Bound Brook Oil-Less Bearing Co., NJ (b,c,f)
Brockway Pressed Metals, Inc., Pa (a,b,c,f,g)
Bunting Brass & Bronze Co., Ohio (b,c)—Ad p 408
Burgess-Norton Mfg. Co., Ill (a,b,c,f,g)
Ceromet, Inc., Calif (b,c,f,g)
Chicago Powdered Metals Products Co., Ill (a,b,c,f,g)
Cleveland Graphite Bronze Co., Ohio (a,b,c,f,g)
Compacted Metals Corp., Ill (b,c)
CrystalX Corp., Pa (bb,cc,dd,ee)
Diamond Mfg. Co., Pa (a,b,f,g)
Dixon Sintaloy, Inc., Conn (b,c,f,g,h,j)
Eaton Mfg. Co., Powdered Metals Div., Mich (b,c,d,f,g,j)
Eberhart Steel Products, Powdered Metals Div., Ind (b,c)
Engineered Plastics & American Sinterings, Inc., Conn (b,c,f,g)
Ferro Powdered Metals, Inc., Ind (b,c,f,g)
General Metals Powder Co., Ohio (b,c,d,j)
General Motors Corp., Moraine Products Div., Ohio (b,c,f,g)
General Powdered Metal Products, Inc., Holly Corp., Conn (a,b,c,f,g)
General Sintering Corp., Ill (a,b,c,f,g)
Gibson Electric Co., Pa (a,b,c,f)—Ad p 415
Haller, Inc., Mich (b,c,g)
Indar Corp., Ind (a,b,c,f,g)
Indiana Steel Products Co., Ind (a,b,c,f,g)
International Powder Metallurgy Co., Inc., Pa (a,b,c,d,f,g,j)
Johnson Bronze, Pa (b,c)
Keystone Carbon Co., Pa (a,b,c,f,g,h)
Kwikset Powdered Metal Products, Calif (b,c,d,f,g)
Lux Clock Mfg. Co., Inc., Conn (a,b,c,f,g)
Magnetic Core Corp., NY (c)
Mallory, P.R. & Co., Inc., Ind (g)
Merriman Bros., Inc., Mass (b,c,f,g)
Metal Powder Products, Inc., Ohio (b,c,g)
Michigan Powdered Metal Products Co., Mich (a,b,c,f,g)
Micro Metallic Corp., NY (a,b,c,f,g)
Micro-Metals Co., Calif (a,b,c,e,f)
Midwest Sintered Products Corp., Ill (b,c)
Mueller Brass Co., Mich (a,b,c,f,g)—Ad p 397
National Molded Products, Inc., Pa (a,b,c,f,g)
National Moldite Co., NJ (c)
Norwalk Powdered Metals, Inc., Conn (b,c,f,g,j)
Nuclear Metals, Inc., Mass (a,b,c,e,f,g,h)
Pacific Sintered Metals Co., Calif (b,c)
Parker White Metal Co., Pa (b,c,f,g)
Picco, Inc., Calif (c)
Powder Metals Products Co., Pa (a,b,c,f,g)
Powdercraft Corp., SC (a,b,c,f,g)
Precision Metal Products Co., Pa (b,c)
Presmet Corp., Mass (b,c,f,g,j)
Pure Carbon Co., Inc., Pa (c)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (a,b,c,e,f)
Reese Metal Products Corp., Pa (b,c,g)
Republic Steel Corp., Ohio (c)
Russell Mfg. Co., Conn (b)
St. Marys Carbon Co., Pa (b,c,f)
Schwarzkopf Development Corp., NY (a,b,c,e,f)
Sintercast Corp. of America, NY (a,b,c,f,g)
Sintered Metals, Inc., Mass (b,c)
Sparta Foundry Div., Muskegon Piston Ring Co., Mich (c)
Star Heel Plate Co., Inc., NJ (c)
Superior Carbon Products, Inc., Ohio (b,c,f,g)
Supermet Div., Globe Industries, Inc., Ohio (c,g)—Ad p 420
Torrington Co., Conn (a,b,f,g)
United Sintered Alloys, NY (a,b,c,f,g)
U.S. Graphite Co., Div. of Wickes Corp., Mich (b,c,d,f,g,j)
Uniworld Research Corp. of America, Ohio (c,f)
Veremere, E.A., Inc., Calif (a,b,c,f,g)
Wakefield Bearing Corp., Mass (b,c,f,g,h,j)
Wellman, S.K. Co., Ohio (b,c)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
Yale & Towne Mfg. Co., Powdered Metal Products Div., Ill (b,c)

Metallic Coatings

(see Diffusion Coatings; Immersion Coatings; Galvanizers; Electroplaters; Hard Facing Alloys; Preplated Metals; Metallized Coatings)

Metallized Coatings—Spray Metallizers

Alloy Products Corp., Wis
Applied Instruments, Inc., NY
Bisonite Co., Inc., NY
Continental Boiler & Sheet Iron Works, Mo
Farwell Metal Fabricating, Minn
Firth Sterling, Inc., Pa
Flood City Brass & Electric Co., Pa
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., Ind
Jema-American, Inc., NJ
Linde Co., Div. of Union Carbide Corp., NY
McGregor-Michigan Corp., Mich
Metal-Cladding, Inc., NY
Metallizing Co. of America, Ill
Metallizing Co. of Los Angeles, Inc., Calif
Metallizing Engineering Co., Inc., NY —Ad p 148
Metalweld, Inc., Pa
Moore Dry Dock Co., Calif
New Jersey Zinc Co., NY
Parker White Metal Co., Pa
Sandy Hill Iron & Brass Works, NY
Schori Process Div., Ferro-Co Corp., NY
Schwartz Chemical Co., Inc., NY
Southern Galvanizing Co., Md
Superior Plating, Inc., Minn
Tickle, Arthur Engineering Works, Inc., NY
Wall Colmonoy Corp., Stainless Process Div., Mich
Waterbury Cos., Inc., Conn
Zeller Corp., Ohio

Metallized Coatings—Vacuum Metallizers

Adams Plastic Products, Ohio
American Metal Climax, Inc., NY
Amos Molded Plastics Div., Amos-Thompson Corp., Ind
Applied Instruments, Inc., NY
Bee Chemical Co., Ill
Chromium Corp. of America, NY
Closures, Inc., Conn
Coating Products, Inc., NJ
Cohan Epner Co., Inc., NY
Cruver Mfg. Co., Ill
Davis Products Corp., NY
Dobeckmun Co., Div. of Dow Chemical Co., Ohio
Dollin Corp., NJ
Electric Auto-Lite Co., Ohio
Electrolizing Co., Ill
Erie Resistor Corp., Plastics Div., Pa
Eyelet Specialty Div., International Silver Co., Conn
Glidden Co., Paint Div., Ohio
Gomar Mfg. Co., Inc., NJ
Hastings & Co., Inc., Pa
High Vacuum Equipment Corp., Mass
International Optical Co., Inc., NY
Jema-American, Inc., NJ
Kinney Mfg. Div., N.Y. Air Brake Co., Mass
Metallizing Co. of America, Ill
Metaplast Process, Inc., NY
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio
Rochester Div., Consolidated Electrodynamics Corp., NY
St. Eloi Corp., Ohio
Schwartz Chemical Co., Inc., NY
Shelby Instrument Co., Calif
Superior Plastics, Inc., Ill
Swedlow, Inc., Calif
Sylvania Electric Products, Inc., NY

Metallized Coatings—Metallizing Wire

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Alloy Metal Wire Co., Inc., Pa
All-State Welding Alloys Co., Inc., NY
Alphaloy Corp., Div. of Alpha Metals, Inc., Ill
Belmont Smelting & Refining Works, Inc., NY
Carpenter Steel Co., Webb Wire Div., NJ
Colonial Alloys Co., Pa
Crucible Steel Co. of America, Pa
Empire Metal Co., NY
Hayden Wire Works, Inc., Mass
Marlane Development Co., Inc., NY
Metal Goods Corp., Mo
Metallizing Co. of America, Ill
Metallizing Co. of Los Angeles, Inc., Calif
Metallizing Engineering Co., Inc., NY
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa
Roebling's, John A. Sons Corp., NJ
Rotometals, Calif
Stainless and Strip Div., Jones & Laughlin Steel Corp., Mich
Uniworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa
White Metal Rolling & Stamping Corp., NY

Methyl Methacrylate

(see Acrylic Plastics)

Mica

Asheville-Schoonmaker Mica Co., Va (r,z,aa,cc,ee)
Beryl Ores Co., Colo (z,aa,cc)
Concord Mica Corp., NH (aa)
Continental-Diamond Fibre Corp., Del (r,z,cc,ee)
Edgar Plastic Kaolin Co., Fla (aa)
Farnam Mfg. Co., NC (r)
Foote Mineral Co., Pa (aa)
Franklin Mineral Products Co., NC (aa)
Funkhouser Co., Md (aa)
General Electric Co., NY (r)
Hall, C.P. Co., Ohio (aa)
Hayden Mica Co., Inc., Mass (aa)
Industrial Mica Corp., NJ (f,cc)
Insulation Mfrs. Corp., Ill (r,cc,ee)
McGean Chemical Co., Ohio (aa)
Mica Fabricating Co., NJ (r,aa,cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (z,cc,ee)
Micacraft Products, Inc., NJ (r,cc)
Mycalex Corp. of America, NJ (r,z,aa,bb,cc,dd)—Ad p 303
Peerless Products Industries, Ill (r)
Richmond Mica Corp., Va (aa)
Smith Chemical & Color Co., Inc., NY (aa)
Sylvania Electric Products, Inc., Parts Div., Pa (r)

Synthetic Mica Co., Div. of Mycalex Corp. of America, NJ (aa)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
U.S. Mica Co., Inc., Ill (r)

Mineral Wool

(see Inorganic Fibers)

Molding Compounds

(see specific plastic or rubber)

Moldings, Blow

American Can Co., Plastics Div., NY (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (l)
Brown Rubber Co., Inc., Ind (m)
Cadillac Plastic & Chemical Co., Mich (k)
Continental Can Co., Inc., NY (k)
CrystalX Corp., Pa (k)
Davis, Joseph Plastics Co., NJ (k)
Eclipse Plastic Industries, Inc., Fla (k)
Foster Grant Co., Mass (k)
General Plastics Corp., Ohio (k)
General Plastics Mfg. Co., Wash (k,m)
Hohwieler Rubber Co., Inc., Pa (m)
Johnson Rubber Co., Ohio (m)
Lee Rubber & Tire Corp., Pa (m)
Luzerne Rubber Co., NJ (l)
Nalge Co., Inc., NY (k)
Newth Rubber Co., RI (m)
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio (k)
Plax Corp., Conn (k)
Rogers Corp., Conn (m)
Schwab Plastic Corp., Mich (k,m)
Seamless Rubber Co., Conn (m)
Shamban, W.S. & Co., Calif (k)
Sheller Mfg. Corp., Mich (l,m)
Shoe Form Co., Inc., NY (k)
Stockwell Rubber Co., Inc., Pa (m)
Stokes Molded Products Div., Electric Storage Battery Co., NJ (l)
Sun Rubber Co., Ohio (m)
Swedlow Inc., Calif (k,l)
Universal Unlimited, Inc., NY (k)
Wasco Products, Inc., Mass (k)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Whyte Mfg. Co., Inc., NY (k,m)

Moldings, Cold

Achushnet Process Co., Mass (m)
American Hard Rubber Co., Div. of Amerace Corp., NJ (l)
American Insulator Corp., Pa (l)—Ad p 382
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Biggs, Carl H. Co., Inc., Calif (l)
Calfibe, Co., Inc., Calif (l)
Ceilcote Co., Ohio (l)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Dumont Corp., Calif (l)
Enflo Corp., NJ (l)
Foss Mfg. Co., Plastics Div., Id (l)
Garfield Mfg. Co., NJ (l)
Halex Corp., Mich (k)
Heil Process Equipment Corp., Ohio (l)
Hohwieler Rubber Co., Inc., Pa (m)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (l)
Rostone Corp., Ind (l)
Seamless Rubber Co., Conn (m)
Schorl Process Div., Ferro-Co Corp., NY (l)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (l)
Warminster Fiberglass Co., Pa (l)

Moldings, Compression

Acadia Synthetic Products Div., Western Felt Works, Ill (m)
Ackerman Plastic Molding Div., Consolidated Iron-Steel Mfg. Co., Ohio (l)
Acushnet Process Co., Mass
Admiral Corp., Molded Products Div., Ill (l)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (l)
Alcylite Plastics & Chemical Corp., Calif (l)
Allegheny Plastics, Inc., Pa (k)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l,m)
American Insulator Corp., Pa (l)—Ad p 382
American Plastics Corp., NY (l)
American Sinterings Div., Engineered Plastics, Inc., Conn (l)
Anderson Assoc., Inc., Ohio (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Atlantic India Rubber Works, Inc., Ill (m)
Auburn Mfg. Co., Conn (k,m)—Ad p 420
Auburn Plastics, Inc., NY (k,l)
Automotive Rubber Co., Inc., Mich (m)
Bangor Plastics Inc., Mich (l)
Beck, I. & Sons, Inc., NY (k)
Belko Corp., Md (m)
Boonton Molding Co., NJ (k)
Camfield Fiberglass Plastics, Inc., Mich (l)
Canfield, H.O. Co., Va (l,m)
Capac Mfg. Corp., Mich (l,m)
Chicago Gasket Co., Ill (l)
Chicago Molded Products Corp., Ill (l)
Chicago Molded Products Corp., Custom Molding Div., Ill (l)
Chicago Rawhide Mfg. Co., Ill (k,m)—Ad p 257
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (m)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (k,m)
Colt's Plastics Co., Inc., Conn (l,m)
Conneaut Rubber & Plastics Co., Div., of U.S. Stoneware Co., Ohio (k,l,m)
Connecticut Hard Rubber Co., Conn (m)
Consolidated Molded Products Corp., Pa (l)—Ad p 399
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Crane Packing Co., Ill (k)
Curtiss-Wright Corp., Plastics Div., NY (l)
Curtiss-Wright Corp., Utica Div., Mich (l)
Davidson Rubber Co., Mass (l,m)
Dayton Rubber Co., Ohio (m)
Dimco-Gray Co., Ohio (l)
Disogrin Industries, Inc., NY (m)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k)
Dumont Corp., Calif (l)—Ad p 410
Electric Auto-Lite Co., Ohio (k,l)
Enflo Corp., NJ (l)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Faultless Rubber Co., Ohio (m)
Fiber Glass Industries, Inc., NY (l)
Fibercast Div., Youngstown Sheet & Tube Co., Okla (l)
Fiberglass Ohio Inc., Ohio (l)
Firestone Tire & Rubber Co., Ohio (m)
Garfield Mfg. Co., NJ (l)
Garlock Packing Co., NY (k,m)
Gatke Corp., Ill (l)
Geauga Industries Co., Ohio (m)
General American Transportation Corp., Ill (k,l)
General American Transportation Corp., Plastics Div., Ill (k,l)—Ad p 425
General Electric Co., Chemical & Metallurgical Div., Ill (l)
General Electric Co., Plastics Dept., Ill (l,m)
General Gasket, Inc., Conn (m)
General Industries Co., Molded Plastic Div., Ohio (l)
Glass Reinforced Plastics Corp., Ohio (l)
Glastic Corp., Ohio (l)—Ad p 290
Goodrich, B.F. Industrial Products Co., Ohio (k)
Goshen Rubber Co., Inc., Ind (m)—Ad p 396
Grimes Mfg. Co., Plastic Research Products Div., Ohio (l)
Halogen Insulator & Seal Corp., Ill (l)
Haveg Industries, Inc., Del (l)
Hawkeye Rubber Mfg. Co., Iowa (m)
Hawley Products Co., Ill (l) (m)
Hays Mfg. Co., Pa (l)
Hohwieler Rubber Co., Inc., Pa (m)
Insulation Products Co., Pa (l)
International Packings Corp., NH (m)
Jersey Plastic & Die Casting Co., NJ (l)
Johnson Rubber Co., Ohio (m)
Judsen Rubber Works, Inc., Ill (m)
Kirkhill Rubber Co., Calif (m)
Kuhn & Jacob Molding & Tool Co., NJ (l)
Kurz Kasch, Inc., Ohio (l)
Lamtex Industries, Inc., NY (l)
Lavelle Rubber Co., Ill (m)
Lee Rubber & Tire Corp., Pa (m)
Lewis, G.B. Co., Wis (l)—Ad p 394
Lone Star Plastics Co., Inc., Tex (l)
Loranger Mfg. Corp., Pa (l)
Lunn Laminates, Inc., NY (l)
Luzerne Rubber Co., NJ (k,l)
Mack Molding Co., NJ (l)
Maloney, F.H. Co., Tex (l,m)
Martin Rubber Co., Inc., NJ (m)
Mesa Plastics Co., Calif (l)
Micarta Div., Westinghouse Electric Corp., SC (k,l,m)
Mid-States Rubber Products, Inc., Ind (m)
Midwest Molding & Mfg. Co., Ill (l)
Minnesota Rubber Co., Minn (l,m)
Modern Plastics Corp., Mich (l)
Molded Fiber Glass Co., Ohio (l)
Morrell, George Corp., Mich (l)
Moxness Products, Inc., Wis (l,m)—Ad p 407
National Lock Co., Ill (l)
Newth Rubber Co., RI (m)
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio (l)
Pacific Moulded Products Corp., Calif (m)
Paeco Rubber Co., Inc., Ohio (k,l,m)
Panelyte Div., St. Regis Paper Co., NY (l)
Parker Appliance Co., Rubber Products Div., Ohio (m)
Parker Seal Div., Parker-Hannifin Corp., Ohio (m)
Parker, Stearns & Co., Inc., NY (m)
Perry Plastics, Inc., Pa (k,l)
Plastic Masters, Inc., Mich (l)
Plastic Products Corp., Ohio (l)
Plasticrafters, Inc., Ill (l)
Precision Rubber Products Corp., Ohio (m)
Prince Rubber Co., Inc., NY (k,l,m)
Raybestos-Manhattan, Inc., NJ (l,m)
Regal Plastic Co., Mo (l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Resistoflex Corp., NJ (k)
Richardson Co., NY (l)
Riverside Plastics Corp., NY (l)
Rogers Corp., Conn (l,m)
Rogers, V.F. Plastic Molding, Colo (l,m)
Romar Plastics, Inc., Ill (l)
Rostone Corp., Ind (l)
Roth Rubber Co., Ill (l,m)
Russell Reinforced Plastics Corp., NY (l)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

St. Clair Rubber Co., Mich (m)
Sealview Plastics, Inc., Pa (l)
Shamban, W.S. & Co., Calif (k)
Shaw Insulator Co., NJ (l)
Sheller Mfg. Corp., Mich (k,l,m)
Sierra Engineering Co., Calif (m)
Sillcocks Miller Co., NJ (k)
Southern Plastics Co., SC (l)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Spencer Rubber Co., Conn (m)
Stalwart Rubber Co., Ohio (m)
Standard Plastics Co., Mass (l)
Stillman Rubber Co., Calif (m)
Stockwell Rubber Co., Inc., Pa (k,l,m)
Stokes Molded Products Div., Electric Storage Battery Co., NJ (l)
Stowe-Woodward, Inc., Mass (m)
Structural Fibers, Inc., Ohio
(l)
Sun Rubber Co., Ohio (m)
Swedish Crucible Steel Co., Mich (k)
Swedlow Plastics Corp., Ohio (l)
Sylvania Electric Products, Inc., Parts Div., Pa
(l)
Synthane Corp., Pa (l)
Thermoid Div., H.K. Porter Co., Pa (l)
Tingley Rubber Corp., NJ (m)
Toledo Industrial Rubber Co., Ohio (l,m)
Toyad Corp., Pa (k)
Trostel, Albert Packing, Ltd., Wis (m)
Tyler Rubber Co., Mass (m)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ
(k,l)
U.S. Rubber Co., Mechanical Goods Div., Ind (l)
U.S. Stoneware Co., NY (k,l)
Vulcanized Rubber & Plastics Co., Pa (m)
Warminster Fiberglass Co., Pa (l)
Waterbury Cos., Inc., Conn (l)
Wesbar Stamping Corp., Wis (m)
Western Felt Works, Ill
(l,m)
Westlake Plastics Co., Pa (k)
Whitso, Inc., Ill (l)
Williams - Bowman Rubber Co., Ill
(l,m)
Woodall Industries, Inc., Mich (k,l)
Wyatt's Plastics, Inc., Tex (l,m)
Yale Rubber Mfg. Co., Mich (m)
Zenith Plastics Co., Calif (l)

Moldings, Injection

A & A Die Casting Co., Calif (k)
aaRBee Plastic Co., Calif (k)
Acushnet Process Co., Mass
(m)
Admiral Corp., Molded Products Div., Ill (k)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (k)
American Agile Corp., Ohio (k)
American Can Co., Plastics Div., NY (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ
(k,m)
American Insulator Corp., Pa
(k,m)—Ad p 382
American Plastics Corp., NY (k)
Amos Molded Plastics Div., Amos-Thompson Corp., Ind (k)
Anderson Assoc., Inc., Ohio (k)
Anthes Force Oiler Co., Iowa (k,l)
Auburn Mfg. Co., Conn
(k,m)—Ad p 420
Auburn Plastics, Inc., NY (k,m)
Auburn Rubber Co., Inc., Ind (k)
Belko Corp., Md (m)
Booker & Wallestad, Inc., Minn (k)
Boonton Molding Co., NJ (k)
Bridgeport Moulded Products, Inc., Conn (k)
Buckeye Molding Co., Ohio (k)
Burwood Products Co., Mich (k)
Byrd Plastics, Inc., Pa (k)
Cambridge-Panelyte Molded Plastics Co., Div. of St. Regis Paper Co., Ohio (k)
Campro Co., Ohio (k)
Canfield, H.O. Co., Va (l,m)
Carlon Products Corp., Ohio (k)
Celluplastic Corp., NJ (k)
Chicago Molded Products Corp., Ill
(k)—Ad p 380
Chicago Molded Products Corp., Custom Molding Div., Ill (k)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (m)
Clover Industries, Inc., NY (k)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works Co., Ohio (k)
Colt's Plastics Co., Inc., Conn (k)
Comet Metal Products Co., Inc., NY (k)
Commercial Plastics Co., Ill (k)
Commercial Plastics Co., Associated Plastic Div., Mich (k)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (k,l,m)
Consolidated Molded Products Corp., Pa
(k)—Ad p 399
Continental Can Co., Inc., NY (k)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k)
Cruver Mfg. Co., Ill (k)
CrystalX Corp., Pa (k)
Curtiss-Wright Corp., Plastics Div., NY (k)
Danielson Mfg. Co., Conn (k)
Dayton Rogers Mfg. Co., Minn (k,l)
Denver Plastics, Inc., Colo (k)
Detroit Macoid Corp., Mich (k,m)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k,m)
Electric Auto-Lite Co., Ohio (k)
Engineered Nylon Products, Inc., Ind (k)
Erie Resistor Corp., Plastics Div., Pa (k)
Fabricon Products Div., Eagle-Picher Co. Mich
(k)
Fiberglass Ohio Inc., Ohio (l)
Foster Grant Co., Mass (k)
Franklin Plastics, Inc., Pa (k)
Fry Plastics Co., Calif (k)
Galigher Co., Utah (k,l)
Garlock Packing Co., NY (k)
Geauga Industries Co., Ohio (m)
General American Transportation Corp., Ill (k)
General American Transportation Corp., Plastics Div., Ill
(k)—Ad p 425
General Electric Co., Chemical & Metallurgical Div., Ill (k)
General Electric Co., Plastics Dept., Ill (k)
General Industries Co., Molded Plastic Div., Ohio (k)
Glass Laboratories, Inc., NY (k)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Gossett and Hill Co., Ill (k)
Gries Reproducer Corp., NY
(k)—Ad p 388
H & R Industries, Pa (k)
Hauser Products, Inc., Ill (l)
Hewitt-Robins, Inc., Conn (m)
Hungerford Plastics Corp., NJ (k,m)
Jamison Plastic Corp., NY (k)
Jersey Plastic & Die Casting Co., NJ (k)
Jet Specialties Co., Inc., Calif (k)
Johnson Plastic Corp., Ohio (k,m)
Judsen Rubber Works, Inc., Ill (m)
Keolyn Plastics, Inc., Ill (k)
Kirk, F.J. Co., Inc., Mass (k)
Lancaster Glass Corp., Ohio (k)
Lee Rubber & Tire Corp., Pa (m)
Lincoln Molded Plastics, Inc., Ohio (k)
Lone Star Plastics Co., Inc., Tex (k)
Loranger Mfg. Corp., Pa (k)
Luminous Resins, Inc., Ill (k)
Luzerne Rubber Co., NJ (k)
Mack Molding Co., NJ (k)
Mallory, P.R. Plastics, Inc., Ill (k)
Maloney, F.H. Co., Tex (k)
Michigan Plastic Products, Inc., Mich (k)
Midwest Molding & Mfg. Co., Ill (k)
Mimosa Corp., Ind (k)
Minnesota Plastics Corp., Minn (k,m)
Minnesota Rubber Co., Minn (l,m)
Modern Plastics Corp., Mich (k)
Moxness Products, Inc., Wis
(k)
Nalge Co., Inc., NY (k)
National Lock Co., Ill (k)
Norgren-Stemac, Inc., Colo (k)
Nosco Plastics Co., Pa (k)
Nylon Molded Products Corp., Ohio (k)
Nyloncraft, Inc., Ind (k)
Ohio Rubber Co., Ohio (k)
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio (k)
Paeco Rubber Co., Inc., Ohio (k,l,m)
Panelyte Div., St. Regis Paper Co., NY (k)
Parker Seal Div., Parker-Hannifin Corp., Ohio (m)
Pee Wee Molding Corp., NY (k)
Peoria Plastic Co., Ill (k)
Perfex Plastics, Inc., Ill (k)
Perry Plastics, Inc., Pa (k,l)
Pipco International Corp., Sub. of Plastiglide Mfg. Corp., Calif (k)
Plastic Engineering, Inc., Ohio (k)
Plastic Masters, Inc., Mich (k)
Plasticrafters, Inc., Ill (k,m)
Plastiglide Mfg. Corp., Calif (k)
Plax Corp., Conn (k)
Plymouth Industrial Products, Wis (k)
Porter, William Co., Calif (k)
Precision Plastics Co., Pa (k)
Prince Rubber Co., Inc. NY (k,m)
Pyro Plastics Corp., NJ (k)
Quinn-Berry Corp., Pa (k)
Raybestos-Manhattan, Inc., NJ (m)
Rogers, V.F. Plastic Molding, Colo (k)
Romar Plastics, Inc., Ill (k)
St. Clair Rubber Co., Mich (m)
Sanford Plastics Corp., NY (k)
Santay Corp., Ill (k)
Saran Lined Pipe Co., Mich (k)
Schaefer-Hausner Corp., NY (k)
Schwab Plastic Corp., Mich (k)
Shamban, W.S. & Co., Calif (k)
Shaw Insulator Co., NJ (k)
Sheller Mfg. Corp., Mich (k,l,m)
Sillcocks Miller Co., NJ (k)
Sinko Mfg. & Tool Co., Ill (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Standard Plastics Co., Mass (k)
Sterling Molders, Inc., NY (k)
Stockwell Rubber Co., Inc., Pa (m)
Stokes Molded Products, Div. of Electric Storage Battery Co., NJ (l)
Superior Plastics, Inc., Ill (k)
Sylvania Electric Products, Inc., Parts Div., Pa
(k)
Tingley Rubber Corp., NJ (k)
Toledo Industrial Rubber Co., Ohio (l, m)
Tri-State Plastic Molding Co., Ky (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ
(k)—Ad p 393
U.S. Rubber Co., Mechanical Goods Div., Ind (k)
United-Carr Fastener Corp., Mass (k,l)
Vulcanized Rubber & Plastics Co., Pa (k,m)
Wagner Plastic Corp., NJ (k)
Waterbury Cos., Inc., Conn (k)
Western Felt Works., Ill
(l,m)
Westlake Plastics Co., Pa (k)
Whyte Mfg. Co., Inc., NY (k,m)
Zenith Plastics Co., Calif (l)

Moldings, Reinforced Plastics

(see Laminates)

Moldings, Sheet

(sheet formed parts)

Allied Resinous Products, Inc., Ohio (k)
Allis Rubber Div., Chicago-Allis Mfg. Corp., Ill (m)
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ
(k,l)
American Plastics Corp., NY (k)
Auburn Rubber Co., Inc., Ind (k)
Blank, Arthur & Co., Inc., Mass (k)
Borkland Mfg. Co., Ind (k)
Brown Rubber Co., Inc., Ind (m)
Cadillac Plastic & Chemical Co., Mich (k,l)
Cambridge-Panelyte Molded Plastics Co., Div. of St. Regis Paper Co., Ohio (k)
Canfield, H.O. Co., Va (l,m)
Carroll, J.B. Co., Ill (k)
Colonial Art Co., Inc., Mass (k)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (k,m)
Connecticut Hard Rubber Co., Conn (m)
Consolidated Molded Products Corp., Pa
(k)—Ad p 399
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
CrystalX Corp., Pa (k)
Curbell, Inc., NY (k)
Duplican Corp., Mass (k)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Dura Plastics of New York, Inc., NY (k)
Enflo Corp., NJ (l)
Fabricon Products Div., Eagle-Picher Co., Mich
(l)
Falge Engineering Corp., Md (k)
Fiber Glass Industries, Inc., NY (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Foster Grant Co., Mass (k)
Fry Plastics Co., Calif (k)
Galigher Co., Utah (k)
Garlock Packing Co., NY (k,m)
General American Transportation Corp., Ill (k)
General American Transportation Corp., Plastics Div., Ill
(k)—Ad p 425
General Electric Co., Chemical & Metallurgical Div., Ill (m)
General Plastics Corp., Ind (k)
General Plastics Mfg. Co., Wash (k,m)
General Tire & Rubber Co., Ind (l)
Glastic Corp., Ohio
(l)
H & R Industries, Pa (k)
Haveg Industries, Inc., Del (l)
Hays Mfg. Co., Pa (l)
Heil Process Equipment Corp., Ohio (l)
Hewitt-Robins, Inc., Conn (m)
Hohwieler Rubber Co., Inc., Pa (m)
Klise Mfg. Co., Mich (k)
Lone Star Plastics Co., Inc., Tex (k)
Luminous Resins, Inc., Ill (k)
Lunn Laminates, Inc., NY (k,l)
Lus-Trus Corp., Mich (k)
Luzerne Rubber Co., NJ (k,l)
Marblette Corp., NY (l)
Masland Duraleather Co., Pa (k)
Mica Insulator Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (k,l)
Midwest Plastic Products Co., Ill (k)
Minnesota Mining & Mfg. Co., Minn (l)

Nalge Co., Inc., NY (k)
National Vulcanized Fibre Co., Del (l)
Newth Rubber Co., RI (m)
Nopco Chemical Co., NJ (l)
O'Sullivan Rubber Corp., Va (k)
Panelyte Div., St. Regis Paper Co., NY (k)
Plastic Products Corp., Ohio (k)
Pyro Plastics Corp., NJ (k)
Pyrosil, Inc., Ohio (l)
Quelcor, Inc., Pa (k)
Regal Plastic Co., Mo (k)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Rogers Corp., Conn (l,m)
St. Clair Rubber Co., Mich (m)
Schori Process Div., Ferro-Co Corp., NY (l)
Sealview Plastics, Inc., Pa (k)
Seamless Rubber Co., Conn (m)
Shamban, W.S. & Co., Ind (k)
Shoe Form Co., Inc., NY (k)
Sillcocks Miller Co., NJ (k)
Snyder Mfg. Co., Inc., Ohio (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Strick Plastic Co., Pa (k,m)
Superior Plastics, Inc., Ill (k)
Swedlow, Inc., Calif (k,l)
Synthane Corp., Pa (l)
Toyad Corp., Pa (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)
U.S. Rubber Co., Mechanical Goods Div., Ind (k)
Universal Unlimited, Inc., NY (k)
Valley-National Corp., Conn (k)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (m)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Williams - Bowman Rubber Co., Ill (l,m)
Woodall Industries, Inc., Mich (k)
Wyatt's Plastics, Inc., Tex (k)

Moldings, Slush

(plastics and rubber)

American Agile Corp., Ohio (k)
Automotive Rubber Co., Inc., Mich (m)
Boonton Molding Co., NJ (m)
Borden Co., Chemical Div., NY (k)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (m)
Dennis Chemical Co., Mo (k)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k)
Dumont Corp., Calif (l)
Hungerford Plastics Corp., NJ (k,m)
Minnesota Rubber Co., Minn (l)
Munray Products Div., Fanner Mfg. Co., Ohio (k,l,m)
Pyrosil, Inc., Ohio (l)
Sheller Mfg. Corp., Mich (k,l,m)
U.S. Stoneware Co., Ohio (k)
Wyatt's Plastics, Inc., Tex (k)

Moldings, Transfer

Accurate Molding Corp., NY (l)
Acushnet Process Co., Mass (m)
Admiral Corp., Molded Products Div., Ill (l)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (l)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l)
American Insulator Corp., Pa (l)—Ad p 382
American Plastics Corp., NY (l)
American Sinterings Div., Engineered Plastics, Inc., Conn (l)
Auburn Mfg. Co., Conn (k)—Ad p 420
Auburn Plastics, Inc., NY (l)
Automotive Rubber Co., Inc., Mich (m)
Bangor Plastics, Inc., Mich (l)
Belko Corp., Md (m)
Biwax Corp., Ill (l)
Booker & Wallestad, Inc., Minn (l)
Boonton Molding Co., NJ (k)
Bridgeport Moulded Products, Inc., Conn (l)
Canfield, H.O. Co., Va (l,m)
Capac Mfg. Corp., Mich (l,m)
Chicago Molded Products Corp., Ill (l)—Ad p 380
Chicago Molded Products Corp., Custom Molding Div., Ill (l)
Chicago Rawhide Mfg. Co., Ill (k,m)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (m)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (k,m)
Colt's Plastics Co., Inc., Conn (l)
Consolidated Molded Products Corp., Pa (l)—Ad p 399
Continental Rubber Works, Pa (m)
Dayton Rogers Mfg. Co., Minn (k,l)
Dayton Rubber Co., Ohio (m)
Dayton Rubber Co., Molded Products Div., Mich (l)
Dimco-Gray Co., Ohio (l)
Disogrin Industries, Inc., NY (m)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k)
Faultless Rubber Co., Ohio (m)
Fiberglass Ohio Inc., Ohio (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (k)
Galigher Co., Utah (m)
Garfield Mfg. Co., NJ (l)
Garlock Packing Co., NY (k,m)
General American Transportation Corp., Ill (k,l)
General Electric Co., Chemical & Metallurgical Div., Ill (l)
General Electric Co., Plastics Dept., Ill (l,m)
General Industries Co., Molded Plastic Div., Ohio (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Grimes Mfg. Co., Plastic Research Products Div., Ohio (l)
Haveg Industries, Inc., Del (l)
Hawkeye Rubber Mfg. Co., Iowa (m)
Hohwieler Rubber Co., Inc., Pa (m)
Houghton, E.F. & Co., Pa (m)
Insulation Products Co., Pa (l)
Johnson Rubber Co., Ohio (m)
Judsen Rubber Works, Inc., Ill (m)
Kurz Kasch, Inc., Ohio (l)
Lee Rubber & Tire Corp., Pa (m)
Lone Star Plastics Co., Inc., Tex (l)
Loranger Mfg. Corp., Pa (l)
Luzerne Rubber Co., NJ (k,l)
Mack Molding Co., NJ (l)
Martin Rubber Co., Inc., NJ (m)
Mesa Plastics Co., Calif (l)
Mid-States Rubber Products, Inc., Ind (m)
Midwest Molding & Mfg. Co., Ill (l)
Minnesota Rubber Co., Minn (l,m)
Moxness Products, Inc., Wis (l,m)
National Lock Co., Ill (l)
Paeco Rubber Co., Inc., Ohio (k,l,m)
Panelyte Div., St. Regis Paper Co., NY (l)
Parker Appliance Co., Rubber Products Div., Ohio (m)
Parker Seal Div., Parker-Hannifin Corp., Ohio (m)
Perry Plastics, Inc., Pa (l)
Plastic Research Products Co., Div. of Grimes Mfg. Co., Ohio (l)
Plasticrafters, Inc., Ill (l)
Porter, William Co., Calif (l)
Precision Rubber Products Corp., Ohio (m)
Raybestos-Manhattan, Inc., NJ (m)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Resistoflex Corp., NJ (k)
Richardson Co., NY (l)
Rogers, V.F. Plastic Molding, Colo (l,m)
Romar Plastics, Inc., Ill (l)
Rostone Corp., Ind (l)
Roth Rubber Co., Ill (m)
St. Clair Rubber Co., Mich (m)
Seamless Rubber Co., Conn (m)
Shaw Insulator Co., NJ (l)
Sheller Mfg. Corp., Mich (k,l,m)
Sierra Engineering Co., Calif (m)
Southern Plastics Co., SC (l)
Standard Plastics Co., Mass (l)
Stockwell Rubber Co., Inc., Pa (m)
Stokes Molded Products, Div. of Electric Storage Battery Co., NJ (l)
Stowe-Woodward, Inc., Mass (m)
Sun Rubber Co., Ohio (m)
Sylvania Electric Products, Inc., Parts Div., Pa (l)
Tingley Rubber Corp., NJ (m)
Toledo Industrial Rubber Co., Ohio (l,m)
Trostel, Albert Packing, Ltd., Wis (m)
U.S. Rubber Co., Mechanical Goods Div., Ind (l)
Vulcanized Rubber & Plastics Co., Pa (m)
Waterbury Cos. Inc., Conn (l)
Western Felt Works, Ill (l,m)
Whitso, Inc., Ill (l)
Williams - Bowman Rubber Co., Ill (l,m)
Wyatt's Plastics, Inc., Tex (l,m)

Molybdenum and Its Alloys

Alloy Metal Products, Inc., Iowa (o,w)
Alpha Metals, Inc., NJ (cc,dd)
Amalgamated Steel Corp., Ohio (o,bb)
American Metal Climax, Inc., NY (o,q,z,aa,bb,cc,dd)
American Nickel Alloy Mfg. Corp., NY (w,aa)
American Silver Co., NY (v,dd,ee,ff)
Associated Engineering & Mfg. Corp., NJ (n,o,aa,bb,cc,dd,ee,ff)
Belmont Smelting & Refining Works, Inc., NY (o,w,aa)
Bishop, J. & Co. Platinum Works, Pa (ff)
Bridgeport Brass Co., Conn (ee)
Cleveland Tungsten Inc., Ohio (aa,bb,ee)
Climax Molybdenum Div., American Metal Climax, Inc., NY (o,q,w,z,bb,cc,dd)
Crucible Steel Co. of America, Titanium & Vacuum Metals Product Div., Pa (o,q,w,z,cc,dd)
Damascus Tube Co., Pa (ee)
Electronic Parts Mfg. Co., Inc., NJ (bb,ee,ff)
Elmet Div., North American Phillips Co., Inc., Me (o,w,z,aa,bb,cc,dd,ff)
Fansteel Metallurgical Corp., Ill (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad pp 158, 159
General Electric Co., Lamp Metals & Components Dept., Ohio (o,q,w,aa,bb,cc,dd,ff)
Hamilton Watch Co, Precision Metals Div., Pa (v,dd,ff)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (aa,ff)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Mallory, P.R. & Co., Inc., Ind (aa,bb)
Mallory-Schwarzkopf Metals, Inc., NY (o,v,w,z,bb,cc,dd,ee,ff)
Metal & Thermit Corp., NJ (w)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metallizing Engineering Co., Inc., NY (ff)
Molybdenum Corp. of America, Pa (o,w,z,aa,bb,cc,dd)
National-Standard Co., Mich (ff)
North American Phillips Co., Inc., Me (aa)
Nuclear Metals, Inc., Mass (w,ee)
Oregon Metallurgical Corp., Ore (w)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Reduction & Refining Co., NJ (q,w,aa,bb,ff)
Shieldalloy Corp., NJ (aa)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (n,w,aa,bb,ff)
Tube Distributors Co., Inc., NY (ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Universal-Cyclops Steel Corp., Pa (o,q,z,cc)
Utica General Jobbing Foundry, Inc., NY (aa)
Wah Chang Corp., NY (n,aa,bb,ff)—Ad p 146
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)

Monel

(see Nickel)

Neoprene

(see Chloroprene Rubber)

Nickel and Its Alloys

Advance Stamping Co., Miuh (dd)
Allied Research Products, Inc., Md (n)
Alloy Metal Powders, Inc., NY (aa)
Alloy Metal Products, Inc., Iowa (o,w)
Amalgamated Steel Corp., Ohio (o,bb)
American Metal Climax, Inc., NY (aa)
American Nickel Alloy Mfg. Corp.,NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (n,w)
Arcos Corp., Pa (ff)
Auld, D.L. Co., Ohio (n)
Austenal Co., Div. of Howe Sound Co., NY (w)
Bart Mfg. Corp., NJ (aa)
Belmont Smelting & Refining Works, Inc., NY (n,o,w,aa)—Ad p 159
Biddle Screw Products Co., Ind (bb,ee)
Bishop, J. & Co. Platinum Works, Pa (ee,ff)
Bridgeport Brass Co., Conn (bb,cc,dd,ee,ff)
Brinkerhoff Brass & Bronze Works, Inc., NY (cc,dd)
Brush Beryllium Co., Ohio (w)
Cannon-Muskegon Corp., Mich (o,v,w,cc,dd,ff)
Carpenter Steel Co., Webb Wire Div., NJ (ff)
Central Fabricators, Inc., Ohio (z,bb,cc,ee)
Chicago Steel Service Co., Ill (o,q,z,bb,cc,dd,ee,ff)
Craft Metal Spinning Co., Ill (cc)
Crucible Steel Co. of America, Titanium and Vacuum Metal Products Div., Pa (o,q,v,z,bb,cc,dd,ee,ff)
Dahlin, C.A. Co., Ill (cc,ee)
Damascus Tube Co., Pa (ee)
Designers Metal Corp., Ill (cc)
Dixon Sintaloy, Inc., Conn (o)
Dormont Mfg. Co., Pa (ee)
Driver, Wilbur B. Co., NJ (v,b,dd,ff)—Ad p 153
Driver-Harris Co., NJ (v,bb,dd,ff)
Electronic Parts Mfg. Co., Inc., NJ (bb,ee,ff)
Elgin National Watch Co., Abrasives Div., Ill (o,bb,dd,ff)
Erskine Precision Wire Corp., Pa (ff)
Federated Metals Div., American Smelting & Refining Co., NY (n)
Firth Sterling, Inc., Pa (o,q,w,bb,dd)
Foote Mineral Co., Pa (aa)
Fox Products Co., Pa (n)
Fromson Orban Co., Inc., NY (ee)
General Plate Div., Metals & Controls Corp., Mass (v,cc,dd)
Gibson Electric Co., Pa. (bb,dd,ff)—Ad p 415
Grand Rapids Brass Co., Mich (z)
Hamilton Watch Co., Precision Metals Div., Pa (v,w,bb,dd)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (aa,ff)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hoskins Mfg. Co., Mich (bb,dd)
International Nickel Co., Inc., NY (n,z,bb,cc,dd,ee,ff)
Jelliff, C.O. Mfg. Corp., Conn (ff)
K. & L. Plating Co., Pa (z)
Kanthal Corp., Conn (bb,dd,ff)
Kelsey-Hayes Co., Mich (o,q,z,cc)
Kelsey-Hayes Co., Utica Metals Div., NY (o,q,w,z,bb,cc,dd,ff)
Kinkead Industries, Inc., Ill (cc,dd)
Lakeland Industries, Minn (z)
Lavin, R. & Sons, Inc., Ill (w)
Leach & Garner Co., Industrial Div., Mass (v,cc,dd,ee,ff)
McGean Chemical Co., Ohio (n,o,bb,dd)
Metal Forming Corp., Div. of Vanadium-Alloys Co., Ind (ee)
Metal Goods Corp., Mo (o,z,bb,cc,dd,ee,ff)
Metal Hybrides, Inc., Mass (aa)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metallizing Engineering Co., Inc., NY (ff)
Metals Disintegrating Co., Inc., NJ (aa)—Ad p 415
Michigan Seamless Tube Co., Mich (ee)
Modern Plating Corp., Ill (n)
National Lead Co., NY (q,w)
National-Standard Co., Mich (ff)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Nesor Alloy Products Co., NJ (ff)
New England Brass Co., Mass (cc,dd)
New Jersey Metals Co., NJ (n,w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Norwalk Powdered Metals, Inc., Conn (aa)
Nuclear Metals, Inc., Mass (w,bb,dd,ee)
Oregon Metallurgical Corp., Ore (w)
Precision Tube Co., Inc., Pa (ee)
Pyron Corp., NY (aa)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Steel & Tubes Div., Ohio (ee)
Rigidized Metals Corp., NY (cc,dd)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (bb,dd,ff)
Rolock, Inc., Conn (ff)
Sandusky Foundry & Machine Co., Ohio (ee)
Sel-Rex Corp., NJ (n,aa)
Seymour Mfg. Co., Conn (n)
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (ee)
Shieldalloy Corp., NJ (aa)
Somers Brass Co., Inc., Conn (v,dd)—Ad p 150
Standard Metals Corp., Mass (ee)
Stevens, Frederic B., Inc., Mich (n)
Superior Steel Corp., Pa (dd)
Superior Tube Co., Pa (ee)
Sylvania Electric Products, Inc., Parts Div., Pa (ff)
Techalloy Co., Inc., Pa (o,v,bb,cc,dd,ff)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Udylite Corp., Mich (n)
Ullmann, Inc., Wis (o,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
United Wire & Supply Corp., RI (ff)
Universal-Cyclops Steel Corp., Pa (o,q,z,bb,cc,dd,ff)
Utica General Jobbing Foundry, Inc., NY (aa)
Utica Metals Div., Kelsey-Hayes Co., NY (o,q,w,z,bb,cc,dd,ff)
Utility Mfg. Co., Mass (bb)
Vanadium-Alloys Steel Co., Pa (aa)
Walmet Alloys Co., Mich (w)—Ad p 80
Wall Colmonoy Corp., Stainless Process Div., Mich (w,aa,bb)
Wall Tube & Metal Products Co., Tenn (ee)
Wallingford Steel Co., Conn (dd,ee)
Waterbury Rolling Mills, Inc., Conn (dd)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)
Whitehead Metal Products Co., Inc., NY (o,q,z,bb,cc,dd,ee,ff)
Wilson, H.A. Co., Div. of Engelhard Industries, Inc., NJ (bb,dd)—Ad p 34
Wisconsin Centrifugal Foundry, Inc., Wis (ee)
Youngstown Welding & Engineering Co., Ohio (ee)

Nickel Silver

(see Copper)

Nitrides

(see Refractories)

Nitrile Rubber

(see Acrylonitrile-Butadiene Rubber)

Nodular Iron

(see Iron)

Nylon

(see Polyamides)

Organic Coatings

(formulations — lacquers, enamels, etc; see also Precoated Metals)

Abalon Precision Mfg. Corp., NY
Acheson Colloids Co., Mich
Acme Plating Co., Ohio
Acme Stamping & Mfg. Co., Pa
Alcylite Plastics & Chemical Corp., Calif
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Allied Research Products, Inc., Md —Ad p 327
Alpha-Molykote Corp., Conn
Aluminum Co. of America, Pa
Amercoat Corp., Calif
American Cynamid Co., Plastics & Resins Div., NY
American Solder & Flux Co., Pa
American-Marietta Co., Ill
Aries Laboratories, Inc., NY
Armitage, J.L. & Co., NJ
Ashtabula Mfg. Co., Ohio
Atlas Mineral Products Co., Pa
Auld, D.L. Co., Ohio
Automotive Rubber Co., Inc., Mich
Avondale Co., Ill
Babbitt Chemical Co., Inc., Mass
Barrett Varnish Co., Ill
Bee Chemical Co., Ill
Berry Bros., Mich
Biggs, Carl H. Co., Inc., Calif
Bisonite Co., Inc., NY
Boatwright Paint & Varnish Works, Inc., Ga
Borden Chemical Div., Borden Co., NY
Bradley Paint Co., Pa
Bradley & Vrooman Co., Ill
Brandt, Charles T., Inc., Md
Burwood Products Co., Mich
Capitol Chemical Co., Ill
Carboline Co., Mo
Ceilcote Co., Ohio
Chemical Coatings Corp., Conn
Chemical Coatings & Engineering Co., Inc., Pa
Chemical Development Corp., Mass
Chemical Process Co., Calif
Chemical Products Corp., RI
Clinton Co., Ill
Commercial Chemical Co., Ohio
Cordo Chemical Corp., Conn
Davis Products Corp., NY
Day, James B. & Co., Ill
Dayton Rubber Co., Ohio
Debevoise Co., NY
Dennis Chemical Co., Mo
Designers Metal Corp., Ill
De Soto Paint & Varnish Co., Tex
Dirilyte Co. of America, Inc., Ind
Doehler-Jarvis Div., National Lead Co., Ohio
Dollin Corp., NJ
Douglas & Sturgess, Calif
du Pont de Nemours, E. I. & Co., Inc., Del
Duralac Chemical Corp., NJ
Dyna-Therm Chemical Corp., Calif
Earl Paint Corp., NY
Egan & Hausman Co., Inc., NY
Egyptian Lacquer Mfg. Co., NJ
Electro Chemical Engineering & Mfg. Co., Pa
Electrofilm, Inc., Calif
Enamelstrip Corp., Sub. of National Steel Corp., Pa
Everlite Corp., Wash
Fidelity Chemical Products Corp., NJ
Flexrock Co., Pa
Forbes Finishes Div., Pittsburgh Plate Glass Co., Ohio
Fox Co., Ohio
Furane Plastics Inc., Calif
Gates Engineering Co., Del
General Electric Co., Chemical Materials Dept., Mass
General Plastics Corp., NJ
General Plastics Mfg. Co., Wash
Glidden Co., Paint Div., Ohio
Globe Paint Works, Inc., Pa
Goodyear Tire & Rubber Co., Chemical Div., Ohio
Graphite Products Corp., Ohio
Grand Rapids Varnish Corp., Mich
Grems Mfg. Co., Ore
Hardman, H.V. Co., Inc., NJ

Haveg Industries, Inc., Del
Hilo Varnish Corp., Mass
Horn, A.C. Co., Inc., Div. of Sun Chemical Corp., NY
Houghton Laboratories, Inc., NY
Industrial Metal Protectives Inc., Ohio
Industrial Polychemical Service, Calif
Interchemical Corp., Finishes Div., NJ
Jamestown Finishes, NY
Jasper Lacquer Co., Inc., Ind
Jema-American, Inc., NJ
Johnson, S.C. & Son, Inc., Wis
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc., Ky
Keystone Refining Co., Inc., Pa
Kish Industries, Inc., Mich
Knight, Maurice A., Ohio
Lacquer Products, Inc., Ohio
Lakewood Metal Products, Inc., Conn
Landau, J. & Co., Inc., NJ
Lithcote Corp., Ill
Lowe Bros. Co., Ohio
Maas & Waldstein Co., NJ
Magnesium Co. of America, Ind
Marblette Corp., NY
McDougall Butler Co., Inc., NY
Mearl Corp., NY
—Ad p 330
Merix Chemical Co., Ill
Metal & Thermit Corp., NJ
Micarta Div., Westinghouse Electric Corp., SC
Michigan Chrome & Chemical Co., Mich
Midland Industrial Finishes Co., Ill
Minnesota Mining & Mfg. Co., Adhesives & Coatings Div., Mich
Minnesota Paints, Inc., Minn
Mirro Aluminum Co., Wis
Mobile Paint Mfg. Co., Inc., Ala
Modern Plating Corp., Ill
Mono-Seal Products Div., Downer, Hunnewell, Inc., Mass
Monsanto Chemical Co., Organic Chemicals Div., Mo
Munray Products Div., Fanner Mfg. Co., Ohio
Narmco Resins & Coatings Co., Calif
National Mfg. Corp., NY
National Polymer Products, Inc., Sub. of Polymer Corp., Pa
Naugatuck Chemical Div., U.S. Rubber Co., Conn
New Jersey Zinc Co., NY
Nikolas, G.J. & Co., Inc., Ill
Nukem Products Corp., NY
Octagon Process, Inc., NY
Owens-Illinois Glass Co., Closure & Plastics Div., Ohio
Paramount Paint & Lacquer Co., Calif
Parker Paint Mfg. Corp., Ind
Pecora, Inc., Pa
Penn Metal Co., Inc., W.Va
Perry-Austen Mfg. Co., NY
Peterson, D.J. Co., Wis
Philadelphia Enameling Works, Inc., Pa
Pierce, F.O. Co., NY
Pierce & Stevens Chemical Corp., NY
Pittsburgh Plate Glass Co., Pa
Plume & Atwood Mfg. Co., Conn
Polymer Industries Inc., Conn
Powell Pressed Steel Co., Ohio
Pratt & Lambert, Inc., NY
Promat Div., Poor & Co., Ill
Queen Products Co., Inc., Ky
Quelcor, Inc., Pa
Radiant Color Co., Calif
Raffi and Swanson, Inc., Mass
Randolph Products Co., NJ
Raybestos-Manhattan, Inc., NJ
Raybestos-Manhattan, Inc., Adhesives Div., Conn
Reynolds Aluminum Supply Co., Ga
Reynolds Chemical Products Co., Mich
Riegel Paper Corp., NY
Rinshed-Mason Co., Mich
Rodney Metals, Inc., NY
Rosco Laboratories, NY
Rubber Corp. of America, NY
Rust-Oleum Corp., Ill
Sauereisen Cements Co., Pa
Schorl Process Div., Ferro-co Corp., NY
Schwartz Chemical Co., Inc., NY
Seal-Peel, Inc., Mich
Sealube Co., Mass
Seaporcel Metals, Inc., NY
Sherwin-Williams Co., Ohio
Simonsen Metal Products Co., Ill
Spraylat Corp, NY
Stanley Chemical Co., Conn
Steel Protection & Chemical Co., Ind
Steelcote Mfg. Co., Mo
Subox, Inc., NJ
Sun Steel Co., Ill
Superior Plastics, Inc., Ill
Textileather Div., General Tire & Rubber Co., Ohio
Thompson and Co., Pa
Tousey Varnish Co., Ill
Tubular Rivet & Stud Co., Mass
Union Chemical Corp., NJ
Union Paste Co., Mass
U.S. Stoneware Co., Ohio
Waterbury Cos., Inc., Conn
Watson-Standard Co., Pa
Wesbar Stamping Corp., Wis
Western Coating Co., Mich
Westinghouse Electric Corp., Pa
Worth Co., Wis
Zeller Corp., Ohio
Zolatone Process, Inc., Calif

Organic Coatings

(coaters)

Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
Aldan Rubber Co., Pa
Alloy Products Corp., Wis
Alpha Molycote Corp., Conn
Aluminum Co. of America, Pa
Aluminum Specialty Co., Wis
American Emblem Co., Inc., NY
American Hard Rubber Co., Div. of Amerace Corp., NJ
Arbonite Corp., Pa
Aries Laboratories, Inc., NY
Ashtabula Mfg. Co., Ohio
Atlas Mineral Products Co., Pa
Auld, D.L. Co., Ohio
Automotive Rubber Co., Inc., Mich
Bee Chemical Co., Ill
Biggs, Carl H. Co., Inc., Calif
Bishopric Products Co., Ohio
Bisonite Co., Inc., NY
Boatwright Paint & Varnish Works, Inc., Ga
Bradley Paint Co., Pa
Brandt, Charles T., Inc., Md
Caspers Tin Plate Co., Ill
Chemical Development Corp., Mass
Coated Coil Corp., NY
Cohan Epner Co., Inc., NY
Colonial Alloys Co., Pa
Cordo Chemical Corp., Conn
Croname, Inc., Ill
Day, James B. & Co., Ill
Debevoise Co., NY
Dirilyte Co. of America, Inc., Ind
Dolin Metal Products, Inc., NY
Dollin Corp., NJ
Douglas & Sturgess, Calif
Dyna-Therm Chemical Corp., Calif
Earl Paint Corp., NY
Electric Auto-Lite Co., Ohio
Electro Chemical Engineering & Mfg. Co., Pa
Electro Technical Div., Sun Chemical Corp., NJ
Electrofilm, Inc., Calif
Emerson & Cuming, Inc., Mass
Enamelstrip Corp., Sub. of National Steel Corp., Pa
Everlite Corp., Wash
Eyelet Specialty Div., International Silver Co., Conn
Falstrom Co., NJ
Farwell Metal Fabricating, Minn
Fletcher Enamel Co., W.Va
Forbes Finishes Div., Pittsburgh Plate Glass Co., Ohio
Foss Mfg. Co., Plastics Div., Id
Fuller, H.B. Co., Minn
Gates Engineering Co., Del
General Plastics Corp., NJ
Glidden Co., Paint Div., Ohio
Globe Paint Works, Inc., Pa
Goodrich, B.F. Industrial Products Co., Ohio
Grand Rapids Brass Co., Mich
Grand Rapids Varnish Corp., Mich
H & R Industries, Pa
Hartglas Co., Ohio
Haveg Industries, Inc., Del
Hayden Wire Works, Inc., Mass
Hilo Varnish Corp., Carpenter-Morton Co., Mass
Industrial Metal Protectives, Inc., Ohio
Jamison Plastic Corp., NY
Johnson, S.C & Son, Inc., Wis
Kelley Mfg. Co., Tex
Kickhaefer Mfg. Co., Wis
Lakewood Metal Products, Inc., Conn
Lithcote Corp., Ill
Lowe Bros. Co., Ohio
Luzerne Rubber Co., NJ
Maas & Waldstein Co., NJ
Magic Chemical Co., Mass
Merix Chemical Co., Ill
Metal-Cladding, Inc., NY
Metalweld, Inc., Protective Coating Div., Pa
Met-L-Wood Corp., Ill
Michigan Chrome & Chemical Co., Mich
Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., Mich
Modern Plating Corp., Ill
Munray Products Div., Fanner Mfg. Co., Ohio
Montague Machine Co., Mass
Narmco Resins & Coatings Co., Calif
National Metal Products Co., Pa
Nikolas, G.J. & Co., Inc., Ill
Norgren-Stemac, Inc., Colo
Pecora, Inc., Pa
Peterson, D.J. Co., Wis
Polacoat, Inc., Ohio
Polymer Corp., Pa
Quelcor, Inc., Pa
Radiant Color Co., Calif
Raffi and Swanson, Inc., Mass
Respro Div., General Tire & Rubber Co., RI
Riegel Paper Corp., NY
Rustproofing & Metal Finishing Corp., Mass
Schori Process Div., Ferro-co Corp., NY
Schwartz Chemical Co., Inc., NY
Smoot-Holman Co., Calif
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio
Steelcote Mfg. Co., Mo
Stirrup Metal Products Corp., NJ
Sun Steel Co., Ill
Superior Plastics, Inc., Ill
Textileather Div., General Tire & Rubber Co., Ohio
Toyad Corp., Pa
Union Chemical Corp., NJ
U.S. Stoneware Co., Ohio
United-Carr Fastener Corp., Mass
Wayne Chemical Products Co., Mich
Woodstock Div., Electric Auto-Lite Co., Ill
Worth Co., Wis
Zolatone Process, Inc., Calif
Zophar Mills, Inc., NY

Organic Coatings —Claddings

(see also Laminates, Metal-Organic)

American Hard Rubber Co., Div. of Amerace Corp., NJ
Arvin Industries, Inc., Ind
Automotive Rubber Co., Inc., Mich
Clad-Rex Corp., Ill
Electro Chemical Engineering & Mfg. Co., Pa
Lithcote Corp., Ill
Metal-Cladding, Inc., NY
National Polymer Products Inc., Sub. of Polymer Corp., Pa
Nukem Products Corp., NY
O'Sullivan Rubber Corp., Plastics Div., Va
Penn Metal Co., Inc., W.Va
Seiberling Rubber Co., Plastics Div., Ohio
Sun Steel Co., Ill
Watson-Standard Co., Pa

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Organic Coatings—Prepainted Metals

Abalon Precision Mfg. Corp., NY
Aluminum Co. of America, Pa
Bridgeport Brass Co., Conn
Caspers Tin Plate Co., Ill
Clad-Rex Corp., Ill
Coated Coil Corp., NY
Cooley, W.J. & Co., Tenn
Dow Chemical Co., Mich
Electro Chemical Engineering & Mfg. Co., Pa
Enamelstrip Corp., Sub. of National Steel Corp., Pa
Fairmont Aluminum Co., W.Va
Falstrom Co., NJ
Fryling Mfg. Co., Pa
Hoofer Mfg. Co., Ill
Kaiser Aluminum & Chemical Sales Inc., Ill
Kees, F.D. Mfg. Co., Neb
Kinkead Industries, Inc., Ill
Lundquist Tool & Mfg. Co., Inc., Mass
Mahon, R.C. Co., Mich
National Metal Products Co., Pa
Olin Mathieson Chemical Corp., Aluminum Div., NY
Penn Metal Co., Inc., W.Va
Philadelphia Steel & Wire Corp., Pa
Republic Steel Corp., Ohio
Reynolds Aluminum Supply Co., Ga
Reynolds Metals Co., Va
Rigidized Metals Corp., NY
Rodney Metals, Inc., NY
Roll Coater, Inc., Ind
Security Sash & Screen Co., Mich
Sharon Steel Corp., Pa
Sillcocks Miller Co., NJ
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio
Sun Steel Co., Ill
Thomas Strip Div., Pittsburgh Steel Co., Pa

Organic Coatings, Strippable

Adhesive Products Corp., NY
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
Amercoat Corp., Calif
American Latex Products Corp., Calif
Angier Adhesives Div., Interchemical Corp., Mass
Atlas Mineral Products Co., Pa
Babbitt Chemical Co., Inc., Mass
Bakelite Co., Div. of Union Carbide Corp., NY
Bee Chemical Co., Ill
Belding Corticelli Industries, NY
Better Finishes & Coatings, Inc., NJ
Bischoff Chemical Corp., NY
Bisonite Co., Inc., NY
Blaco Mfg. Co., Ohio
Borden Chemical Div., Borden Co., NY
Bradley & Vrooman Co., Ill
Carboline Co., Mo
Carey, Philip Mfg. Co., Ohio
Chemical Coatings & Engineering Co., Inc., Pa
Chemical Development Corp., Mass
Chemical Products Corp., RI
Daubert Chemical Co., Ill
Dennis Chemical Co., Mo
De Soto Paint & Varnish Co., Tex
Dip Seal Plastics, Inc., Ill
Diversey Corp., Metal Industries Div., Ill
Dow Chemical Co., Plastics Div., Mich
du Pont de Nemours, E. I. & Co., Inc., Del
Earl Paint Corp., NY
Fidelity Chemical Products Corp., NJ
Fine Organics, Inc., NY
Frost Paint & Oil Corp., Minn
George, P.D. Co., Mo
Glidden Co., Paint Div., Ohio
Globe Imperial Corp., Plastic-Seal Div., Ill
Houghton, E.F. & Co., Pa
Hughes Glue Co., Mich
Interchemical Corp., Finishes Div., NJ
Jamestown Finishes, NY
Johnson, S.C & Son, Inc., Wis
Kinkead Industries, Inc. Ill
Koster-Keunen Mfg. Co. Inc. NY
Lacquer Products, Inc., Ohio
Landau, J. & Co., Inc., NJ
Maas & Waldstein Co., NJ
Metal & Thermit Corp., NJ
Micarta Div., Westinghouse Electric Corp., SC
Michelman Chemicals, Inc., Ohio
Midland Adhesive & Chemical Corp., Mich
Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., Mich
Minnesota Paints, Inc., Minn
Modern Plating Corp., Ill
Morningstar-Paisley, Inc., NY
Munray Products Div., Fanner Mfg. Co., Ohio
Nikolas, G.J. & Co., Inc., Ill
Nukem Products Corp., NY
Octagon Process, Inc., NY
Parker Paint Mfg. Corp., Ind
Pecora, Inc., Pa
Pennsalt Chemicals Corp., Pa
Pierce & Stevens Chemical Corp., NY
Plume & Atwood Mfg. Co., Conn
Poly Resins, Calif
Polyken Sales Div., Kendall Co., Ill
Polymer Chemical Co., Ohio
Polymer Industries, Inc., Conn
Protective Treatments, Inc., Ohio
Puritan Co., Inc., NY
Pyramid Plastics, Inc., Ill
Reynolds Chemical Products Co., Mich
Schwartz Chemical Co., Inc., NY
Seal-Peel, Inc., Mich
Servwell Products Co., Ohio
Spraylat Corp., NY —Ad p 328
Sun Steel Co., Ill
Texas Plastic Development Corp., Tex
Thompson and Co., Pa
Turco Products, Inc., Calif
Union Chemical Corp., NJ
Union Paste Co., Mass
U.S. Rubber Co., NY
U.S. Stoneware Co., Ohio
Valvoline Oil Co., Div. of Ashland Oil & Refining Co., Pa
Watson-Standard Co., Pa
Wayne Chemical Products Co., Mich
Western Coating Co., Mich
Whitfield Chemical Co., Mich
Xylos Rubber Co., Ohio
Zophar Mills, Inc., NY

Oxide Coatings

(see Conversion Coatings)

Oxides

(see Ceramics; Refractories)

Paints

(see Organic Coatings)

Papers

(cellulose, inorganic, synthetic; for industrial use)

Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Auburn Mfg. Co., Conn
Avery Label Co., Decorative Products Div., Ohio
Consolidated Water Power & Paper Co., Wis
Dexter, C.H. & Sons, Inc., Conn
Filpaco Industries, Inc., Ill
Fox Edge Co., Inc., Mass
General Gasket, Inc., Conn
Georgia-Pacific Corp., Ore
Gomar Mfg. Co., Inc., NJ
Hollingsworth & Vose Co., Mass
Insulation Mfrs. Corp., Ill
Johns-Manville Corp., NY
Knowlton Bros., Inc., NY —Ad p 292
Mica Fabricating Co., NJ
Mosinee Paper Mills Co., Wis
National Gasket & Washer Mfg. Co., Inc., NY
Nicolet Industries, Inc., NY
Owens-Illinois Glass Co., Paper Products Div., Ohio
Panelyte Div., St. Regis Paper Co., NY
Plymouth Cordage Co., Mass
Precision Paper Tube Co., Ill
Raybestos-Manhattan, Inc., NJ
Riegel Paper Corp., NY
Rogers Corp., Conn
Spaulding Fibre Co., Inc., NY —Ad p 251
Spruce Pine Mica Co., Inc., NC
Standard Asbestos Mfg. Co., Ill
Standard Washer & Mat, Inc., Conn
Twitchell, E. W., Inc., Pa —Ad p 288
Upson Co., NY
Vellumoid Co., Mass
Victor Mfg. & Gasket Co., Ill
West Virginia Pulp & Paper Co., NY

Perforated Materials

Acme Precision Products, Inc., Ohio (a,b,g,h)
Aluminum Co. of America, Pa (a)
American Metal Products, Inc., Ohio (g)
American Nickel Alloy Mfg. Corp., NY (f)
Atlantic Steel Co., Ga (a,b,g)
BLC Porous Materials Co., Calif (a, b,e,f,g,j,k,l,m)
Biersach & Niedermeyer Co., Wis (a, b,c,f,g)
Blaco Mfg. Co., Ohio (b,g)
Bohn Aluminum & Brass Co., Mich (a)
Brockway Pressed Metals, Inc., Pa (b, c)
Burgess-Norton Mfg. Co., Ill (c)
California Perforated Screen Co., Calif (a,b,c,f,g,j)
Caspers Tin Plate Co., Ill (g)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (b)
Clad-Rex Corp., Ill (a,g)
Clark Perforating Co., Mich (a,b,c,d, f,g,j,k,l,m)
Clendenin Bros., Inc., Md (a,b)
Colonial Alloys Co., Pa (a)
Colorado Fuel & Iron Corp., Colo (g)
Cross Engineering Co., Pa (a,g)
Diamond Mfg. Co., Pa (a,b,c,d,e,f,g,h, j)
Division Lead Co., Ill (d)
Duplex Mfg. Corp., NY (g)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a, b,f,g)
Erdle Perforating Co., Inc., NY (a,b, g,k,l)
Etched Products Corp., NY (a)
Falstrom Co., NJ (a,b,e,g)
Fletcher Enamel Co., W.Va (a,b,c,d,e, f)
Fox Products Co., Pa (c)
General Alloys Co., Mass (a,b,f,g)
Greene, G.G. Corp., Pa (g)
Grigoleit Co., Ill (a,g)
Harrington & King Perforating Co., Inc., Ill (a,b,c,d,e,f,g,h,j,k,l,m)—Ad p 406
Hawkridge Bros. Co., Mass (a)
Hendrick Mfg. Co., Pa (a,b,c,d,e,f,g,h, j)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Ideal Can Co., Mass (g)
Industrial & Furnace Car Div., Irwin-Sensenich Corp., Pa (g)
Kees, F.D. Mfg. Co., Neb (g)
Levinson Steel Co., Pa (g)
Manganese Steel Forge Co., Pa (g)
McCarter Iron Works, Inc., Pa (g)
McNally Pittsburgh Mfg. Co., Kan (a, g)
Melco Wire Products, Calif (a)
Metal Goods Corp., Tex (a,b,f,g)
Mundt, Charles & Sons, NJ (a,b,c,d, e,f,g,h,j,k,l,m)
National Galvanizing Co., Pa (g)
National Lead Construction Co., Inc., NJ (d)
National-Standard Co., Mich (a,b,f,g,h)—Ad p 375
Norwalk Powdered Metals, Inc., Conn (b)
Parker Metal Goods Co., Mass (g)
Perforating Industries, Inc., NJ (k,l)—Ad p 422
Republic Steel Corp., Ohio (g)
Reynolds Metals Co., Va (a)
Rigidized Metals Corp., NY (a,b,f,g,h,j)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Servwell Products Co., Ohio (b,g)
Sillcocks Miller Co., NJ (a,b)
Stainless Metals, Inc., NY (g)
Standard Stamping & Perforating Co., Ill (a,b,g,k,l,m)
Thompson Pipe & Steel Co., Colo (g)
Toepfer & Sons., Inc., Wis (a,b,c,e,f, g,h,j)
Wesbar Stamping Corp., Wis (a)
Whitehead Metal Products Co., Inc., NY (a,b,f)
Whyte, Oliver Co., Inc., NY (a,g)
Wire & Iron Products, Inc., Mich (f, g)
Wrought Washer Mfg. Co., Wis (g)

Permanent Mold Castings

(see Castings)

Phenolics

Ace Plastic Co., NY (bb,cc,dd)
Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p,x,y)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,y)
Anderson Assoc., Inc., Ohio (y)
Archer-Daniels-Midland Co., Minn (y)
Atlas Mineral Products Co., Pa (x)
Auburn Plastic Engineering, Ill (bb,cc)
Baer, N.S. Co., NJ (bb,cc,dd,ee)
Bakelite Co., Div. of Union Carbide Corp., NY (p,u,x,y)
Bisonite Co., Inc., NY (x)
Blank, Arthur & Co., Inc., Mass (cc)
Borden Chemical Div., Borden Co., NY (p)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Calfibe Co., Inc., Calif (cc,ee)
Catalin Corp. of America, NY (p,x)
Chemical Process Co., Calif (x)

Coast Mfg. & Supply Co., Calif
(y)
Colonial Kolonite Co., Ill (bb,cc,ee)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn
(y)
Cordo Molding Products, Inc., NY
(y)
CrystalX Corp., Pa (bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,dd,ee)
Douglas & Sturgess, Calif (x,y)
Dunnican Assoc., NJ (p,y)
Durez Plastics Div., Hooker Chemical Corp., NY
(p,x,y)—Ad pp 252-253
Dyna-Therm Chemical Corp., Calif
(p)
Electrofilm, Inc., Calif (t)
Eljay Corp., Md (bb,cc,dd,ee)
Falge Engineering Corp., Md (t)
Farley & Loetscher Mfg. Co., Plastics Div., Iowa (cc)
Fiberite Corp., Minn
Fiber Glass Industries, Inc., NY (x,cc) (y)—Ad p 259
Fluoro-Plastics Inc., Div. of Flexrock Co., Pa (bb,cc)
Formica Corp., Sub. of American Cyanamid Co., Ohio (bb,cc,dd,ee)
Galigher Co., Utah (bb,cc,dd,ee)
General Electric Co., Chemical Materials Dept., Mass (p,x,y)
General Electric Co., Laminated Products Dept., Ohio
(bb,cc,ee)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Grigoleit Co., Ill (p,s)
Haveg Industries, Inc., Del (p,bb,cc,ee)
Hercules Powder Co., Inc., Del
(p)
Iten Fibre Co., Ohio (bb,cc,dd,ee)
Lewis, J.P. Co., Plastic Products Div., NY (cc)
Kish Industries, Inc., Mich (u,x)
Kurz Kasch, Inc., Ohio (y)
Laminated Plastex Corp., Ohio (x,cc)
Maloney, F.H. Co., Tex (x,y,bb,cc,dd,ee)
Marblette Corp., NY (p,u,x,y,bb,cc,ee)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc,ee)
Micarta Div., Westinghouse Electric Corp., SC (p,x)
Monsanto Chemical Co., Plastics Div., Mass (p,x)
Narmco Resins & Coatings Co., Calif (u,x,y,dd)
National Moldite Co., NJ (y)
National Vulcanized Fibre Co., Del
(bb,cc,dd,ee)
New England Laminates Co., Inc., Conn
(cc)
Nopco Chemical Co., NJ (p)
Norrich Plastics Corp., NY (bb,cc,dd,ee)
Northern Plastics Corp., Wis (cc,dd)
Omni Products Corp., NY (y)
Panelyte Div., St. Regis Paper Co., NY (x,bb,cc,dd,ee)
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Plastics Engineering Co., Wis
(p,x,y,aa)—Ad p 97
Poly Resins, Calif (p,x)
Precision Paper Tube Co., Ill (ee)
Pyrosil Inc., Ohio (x,cc)
Quelcor, Inc., Pa (t)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (x)
Raybestos-Manhattan, Inc., Adhesives Div., Conn
(p,x)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn
(p,x,y)
Reichhold Chemicals, Inc., NY (p,x)
Rezolin, Inc., Calif (p,u,x)
Richardson Co., NY (bb,cc,ee)
Rogers Corp., Conn (y)
Schenectady Varnish Co., Inc., NY (p,x)
Schwab Plastic Corp., Mich (bb,cc,dd,ee)
Spaulding Fibre Co., Inc., NY
(bb,cc,dd,ee)
Spencer Rubber Co., Conn (u)
Strick Plastics Co., Pa (u,cc)
Sun Chemical Corp., Electro Technical Div., NJ (x)
Swedlow, Inc., Calif (cc)
Synco Resins, Inc. Conn (p,x)
Synthane Corp., Pa (bb,cc,dd,ee)
Taylor Fibre Co., Pa
(bb,cc,dd,ee)
Texas Glass Fiber Corp., Tex (y)
Thombert, Inc., Iowa (bb,cc,dd,ee)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY (p,u,x,y)
U.S. Polymeric Chemicals, Inc., Conn (s)
Varcum Chemical Corp., NY (p)
Watertown Mfg. Co., Conn (p,y)
Westlake Plastics Co., Pa (bb,cc,dd,ee)
Wilmington Fibre Specialty Co., Del (bb,cc,ee)

Phosphate Coatings

(see Conversion Coatings)

Phosphor Bronze

(see Copper)

Pipe

(see Tubing)

Plaster Mold Castings

(see Castings)

Plastics

(see specific material and form)

Plate

(see specific metal)

Plated Coatings

(see Electroplated Coatings; Preplated Metals)

Platinum and Platinum Group Alloys

American Metal Climax, Inc., NY (aa)
American Platinum & Silver Div., Engelhard Industries, Inc., NY
(n,v,z,aa,bb,cc,dd,ee,ff)
American Platinum Works, NJ (z)
American Silver Co., NY (v,dd,ee,ff)
Anaconda Co., NY (n,v,cc)
Baker & Co., Inc., NJ (n,o,v,w,z,aa,bb,cc,dd)
Bishop, J. & Co. Platinum Works, Pa
(n,v,z,cc,dd,ee,ff)
Deringer Metallurgical Corp., Ill (cc,dd,ee,ff)
Eastern Smelting & Refining Corp., Mass (n,o,v,w,z,aa,bb,cc,dd,ee,ff)
General Plate Div., Metals & Controls Corp., Mass (n,v,z,bb,cc,dd)
Gibson Electric Co., Pa
(bb,dd,ff)—Ad p 415
Goldsmith Bros. Smelting & Refining Co., Ill (n,o,v,w,z,bb,cc,dd,ff)
Hagstoz, T.B. & Son, Pa (n,cc,dd,ff)
Hamilton Watch Co., Precision Metals Div., Pa (ff)
Handy & Harman, NY
(n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hanovia Chemical & Mfg. Co., NJ (aa)
Hardy, Charles, Inc., Mass (aa)
Hayden Wine Works, Inc., Mass (ff)
Hudsar, Inc., NJ (w)
International Nickel Co., Inc., Platinum Metals Div., NY
Leach & Garner Co., Industrial Div., Mass (n,o,v,bb,cc,dd,ee,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee,ff)
Metals & Controls Corp., Mass (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Nesor Alloy Products Co., NJ (dd,ff)
Ney, J.M. Co., Industrial Div., Conn (z,bb,cc,dd,ff)
Nuclear Metals, Inc., Mass (w)
Sel-Rex Corp., NJ
(n,aa)
Standard Metals Corp., Mass (cc,dd,ff)
Technic, Inc., RI (aa)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (aa,cc,dd,ff)
Wildberg Bros. Smelting & Refining Co., Calif (n,o,v,w,z,aa,bb,cc,dd,ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Wilson H.A. Div., Engelhard Industries, Inc., NJ
(ff)

Plywood

(see Wood)

Polyamides

(nylon)

Ace Plastics Co., NY (bb,dd)
Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,s,y)
American Hard Rubber Co., Div. of Amerace Corp., NJ
(bb,dd,ee)
American Molding Powder & Chemical Co., NY (y)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Anderson Asso., Inc., Ohio (y)
Aries Laboratories, Inc., NY (x)
Auburn Plastic Engineering, Ill (t,bb,cc,ee)
Bamberger, Claude P., Inc., NJ (y)
Belding Corticelli Industries, NY (p,x,y)
Catalin Corp. of America, NY (y)
Chemical Coatings & Engineering Co., Inc., Pa (x)
Chippewa Plastics, Inc., Wis (t)
Colonial Kolonite Co., Ill (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Danielson Mfg. Co., Conn (bb,cc,dd,ee)
du Pont de Nemours, E. I. & Co., Inc., Del
(p,s,y)
Dyna-Therm Chemical Corp., Calif
(p)
Emerson & Cuming, Inc., Mass (p,u,x)
Fiberfil, Inc., Ind (y)
Firestone Plastics Co., Pa (s)
Flexible Tubing Corp., Conn (ee)
Fluoro-Plastics, Inc., Div. of Flexrock Co., Pa (bb,cc)
Foster Grant Co., Mass (p,t,y,ee)
Fox Edge Co., Inc., Mass (s)
Fry Plastics Co., Calif (bb,cc)
General Mills Inc., Chemical Div., Ill (p)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Glass Laboratories, NY (bb,dd)
H & R Industries, Pa (t,bb,cc,dd,ee)
Houghton Laboratories, Inc., NY
(x,y)
Hyde Co., A.L., NJ (bb,cc)
Industrial Rayon Corp., NY (s)
Lus-Trus Corp., Mich (cc)
Moore, Samuel & Co., Ohio (ee)
Muehlstein, H. & Co., Inc., NY (y)
Narmco Resins & Coatings Co., Calif (x,y)
National Polymer Products, Inc., Sub. of Polymer Corp., Pa
(y)—Ad p 230
National Vulcanized Fibre Co., Del
(bb,dd,ee)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa
(t,bb,cc,dd,ee)—Ad p 230

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Raybestos-Manhattan, Inc., Plastic Products Div., Conn (x)
Reichhold Chemicals, Inc., NY (p)
Schwab Plastic Corp., Mich (bb,cc,dd,ee)
Shamban, W.S. & Co., Calif (t,bb,cc,dd,ee)
Southern Plastics Co., SC (bb,cc,dd,ee)
Spencer Chemical Co., Mo (p,x,y)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Thombert, Inc., Iowa (bb,cc,dd,ee)
U. S. Gasket Plastics Div., Garlock Packing Co. NJ (t,bb,cc,dd,ee)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (bb,dd,ee)
Western Plastics Corp., Neb (bb,dd,ee)
Westlake Plastics Co., Pa (t,bb,cc,dd,ee)

Polycarbonate Plastics

Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
General Electric Co., NY (p,y)
General Electric Co., Chemical Materials Dept., Mass (p,t,y)
Mobay Chemical Co., Pa (p,t,y)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa (bb,cc,dd,ee)—Ad p 230
Southern Plastics Co., SC (bb,cc,dd,ee)

Polyesters

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,y)
Alsynite Co. of America, Calif (cc)
American Cynamid Co., Plastics & Resins Div., NY (x)—Ad pp 231-232
American Metaseal Corp., NJ (p)
American Products Mfg. Co., Inc., La (p)
Archer-Daniels-Midland Co., Minn (p)
Atlas Mineral Products Co., Pa (x)
Atlas Powder Co., Chemicals Div., Del (p,x,y)
Auburn Plastic Engineering, Ill (t,bb,cc,ee)
Auburn Plastics, Inc., NY (bb,cc,dd,ee)
Avery Label Co., Decorative Products Div., Ohio (t)
Bakelite Co., Div. of Union Carbide Corp., NY (p,x)
Boonton Molding Co., NJ (x)
Brown Rubber Co., Inc., Ind (u)
Burkart, F. Mfg. Co., Div. of Textron Inc., Mo (u)
Cadillac Plastic & Chemical Co., Mich (t,x,cc)
Calfibe Co., Inc., Calif (cc,ee)
Cast Optics Corp., NJ (cc)
Chemical Process Co., Calif (p,x,y)
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., Ill (cc)
Columbia - Geneva Steel Div., U.S. Steel Corp., Calif (ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn (x,y)
Cordo Molding Products, Inc., NY (y)
Corrulux Div., L.O.F. Glass Fibers Co., Tex (cc)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (f)
Dayton Rubber Co., Ohio (x,y)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Douglas & Sturgess, Calif (x,y) (s,t)
du Pont de Nemours, E. I. & Co., Inc., Del (s,t)
Durez Plastics Div., Hooker Chemical Corp., NY (p,x,y)—Ad pp 252-253
Everlite Corp., Wash (cc)
Falge Engineering Corp., Md (t)
Fiber Glass Industries, Inc., NY (x,y,cc)
Fiberglass Ohio Inc., Ohio (cc)
Flexfirm Products, Calif (s,y)
Flexible Tubing Corp., Conn (ee)
Foam Products, Inc., Pa (u)
Foamade Industries, Mich (u)
Foss Mfg. Co., Plastics Div., Id (x)
Fry Plastics Co., Calif (p,x)
Galigher Co., Utah (p,s,x)
General Electric Co., NY (x)
General Plastics Mfg. Co., Wash (x,cc)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Glass Reinforced Plastics Corp., Ohio (bb,ee)
Glastic Corp., Ohio (y,bb,cc)
Glidden Co., Paint Div., Ohio (p,x)
Goodrich, B.F. Co., Sponge Products Div., Conn (u)
Hall, C.P. Co., Ohio (p)
Haskelite Mfg. Corp., Mich (cc,dd)
Hastings & Co., Inc., Pa (t)
Haveg Industries, Inc., Del (cc)
Hays Mfg. Co., Pa (y,cc)
Heil Process Equipment Corp., Ohio (x,cc)
Interchemical Corp., NY (p,x,y)
Interchemical Corp., Finishes Div., NJ (p)
Kish Industries, Inc., Mich (x)
Laminated Plastex Corp., Ohio (x,cc)
Lewis, G.B. Co., Wis (bb)—Ad p 394
Luminous Resins, Inc., Ill (y)
Maloney, F.H. Co., Tex (x,y)
Micarta Div., Westinghouse Electric Corp., SC (p,y)
Minnesota Mining & Mfg. Co., Minn (s)
Mobay Chemical Co., Mo (p)
Muehlstein, H. & Co., Inc., NY (p)
Narmco Resins & Coatings Co., Calif (x,y,dd)
National Vulcanized Fibre Co., Del (cc,dd)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
Nopco Chemical Co., NJ (p)
Omni Products Corp., NY (p)
Ormond Mfg. Co., Inc., NJ (cc,dd)
Panelyte Div., St. Regis Paper Co., NY (x,y,cc)
Pelron Corp., Ill (p,x,y)
Penn Fibre & Specialty Co., Inc., Pa (cc)
Philrus Products Co., NJ (bb,cc,dd)
Pittsburgh Plate Glass Co., Pa (p,u,x,y)
Plumb Chemical Corp., Pa (y)
Polygon Plastic Co., Ind (bb,ee)
Porter, William Co., Calif (ee)
Precision Paper Tube Co., Ill (ee)
Prince Rubber Co., Inc., NY (bb,cc)
Reichhold Chemicals, Inc., NY (p,u,x)
Robertson, H.H. Co., Pa (p)
Rohm & Haas Co., Pa (x,y)
Roller Reinforced Plastics, Ohio (x,y)
Rubber Corp. of America, NY (u)
Schori Process Div., Ferro-Co Corp., NY (cc,ee)
Schwab Plastic Corp., Mich (u)
Schwartz Chemical Co., Inc., NY (x)
Sheller Mfg. Corp., Mich (u)
Specialty Resins Co., Calif (p,x)
Strick Plastics Co., Pa (u,cc,dd)
Sun Chemical Corp., Electro Technical Div., NJ (p,x)
Swedlow, Inc., Calif (cc)
Texas Plastic Development Corp., Tex (p)
Thalco, Calif (p)
Thermaflow Chemical Corp., Pa (p)
United Shoe Machinery Corp., Mass (x)
U.S. Polymeric Chemicals, Inc., Conn (s)
U.S. Rubber Co., NY (p,u,x)
Varflex Corp., NY (ee)
Wasco Products, Inc., Mass (cc)
Williamson Adhesives, Inc., Ill (y)
Witco Chemical Co., Ill (p,u)
Woodall Industries, Inc., Mich (y)
Zenith Plastics Co., Sub. of Minnesota Mining & Mfg. Co., Calif (u)

Polyethylenes

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Advance Screw Products Co., Inc., Wis (bb)
Aladdin Products Co., NY (t,ee)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,y)
Allied Resinous Products, Inc., Ohio (y,bb,cc,dd,ee)
Alpha Wire Corp., NY (ee)
American Agile Corp., Ohio (bb,cc,dd,ee)
American Hard Rubber Co., Div. of Amerace Corp., NY (bb,dd)—Ad pp 240-241
American Molding Powder & Chemical Co., NY (y)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Anderson Asso., Inc., Ohio (y)
Anesit Co., Ill (ee)
Auburn Plastic Engineering, Ill (t,bb,cc,ee)
Bakelite Co., Div. of Union Carbide Corp., NY (p,y)
Bamberger, Claude P., Inc., NJ (p,y)
Blacher, B., NY (t)
Blank, Arthur & Co., Inc., Mass (t)
Blossom Mfg. Co., Inc., NY (t,cc)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Campco Div., Chicago Molded Products Corp., Ill (t,cc)
Carlon Products Corp., Ohio (t)
Carroll, J.B. Co., Ill (cc)
Carroll Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Catalin Corp. of America, NY (y)
Celanese Plastics Co., Div. of Celanese Corp. of America, NJ (p,t,y,cc)—Ad pp 219-226
Celluplastic Corp., NJ (bb,ee)
Chester Packaging Div., St. Regis Paper Co., NY (t,cc)
Chippewa Plastics, Inc., Wis (t,ee)
Clopay Corp., Ohio (t,cc)
Clover Industries, Inc., NY (y)
Colonial Kolonite Co., Ill (bb,cc,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (t,x,y,bb,cc,dd)
Contour Extrusion Co., NY (t,bb,cc,dd,ee)
Copper and Brass Sales, Inc., Mich (ee)
Coyne & Paddock, Inc., NY (y)
Crescent Plastics, Inc., Ind (ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (s,bb,cc,dd,ee)
Danielson Mfg. Co., Conn (bb)
Dapol Plastics, Inc., Mass (y)
Davis, Joseph Plastics Co., NJ (t,y,bb,cc,dd,ee)
Denver Plastics, Inc., Colo (t,u,bb,cc,dd,ee)
Designers Metal Corp., Ill (cc)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Dow Chemical Co., Plastics Div., Mich (p,t,y)—Ad p 239
du Pont de Nemours, E. I. & Co., Inc., Del (p,y)
Dura-Lee Corp., Mo (t)
Durable Formed Products, Inc., NY (cc,ee)
Durethene Corp., Ill (t)
Eastman Chemical Products, Inc., Sub. of Eastman Kodak Co., Tenn (p,u,y)
Eclipse Plastic Industries, Inc., Fla (bb,cc,dd,ee)
Extruders, Inc., Calif (t)
Falge Engineering Corp., Md (t)
Firestone Plastics Co., Pa (s,t)
Foss Mfg. Co., Plastics Div., Id (t)
Foster Grant Co., Mass (t)
Fox Edge Co., Inc., Mass (s)
Galigher Co., Utah (bb,cc,dd,ee)
Garlock Packing Co., NY (y)
Geauga Industries Co., Ohio (bb,dd)
General Electric Co., NY (t)
General Gasket, Inc., Conn (t,cc)
General Plastics Corp., Ind (cc)
General Plastics Mfg. Co., Wash (cc)
General Tire & Rubber Co., Ind (t,cc)
Genesee Laboratory, Inc., NY (ee)
Gering Products Inc., NJ (t,y)
Glass Laboratories, NY (bb,dd)
Goodrich-Gulf Chemicals, Inc., Ohio (p)
Grace, W.R. & Co., Polymer Chemicals Div., NJ (p,y)
Grigoleit Co., Ill (p,s)
H & R Industries, Pa (t,bb,cc,dd,ee)
Hastings & Co., Inc., Pa (t)
Hercules Powder Co., Inc., Del (p,y)—Ad pp 264-265
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
Jet Specialties Co., Inc., Calif (bb,cc,dd,ee)
KSH Plastics, Inc., Mo (bb,cc,dd)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (cc)
Koppers Co., Inc., Plastics Div., Pa (p,y)
Kuss, R.L. & Co., Inc., Ohio (t)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc)
Maloney, F.H. Co., Tex (y)
Manufacturers Corp., Ohio (ee)
Mason Envelope Co., Inc., NY (t)
Mayon Plastics, Minn (ee)
Midwest Plastic Products Co., Ill (t,cc)
Monsanto Chemical Co., Plastics Div., Mass (p,y)
Moore, Samuel & Co.,Ohio (ee)
Muehlstein, H & Co., Inc., NY (y)
Murray, A.B. Co., Inc., NJ (ee)
Nalge Co., Inc., NY (ee)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
National Polymer Products, Inc., Sub. of Polymer Corp., Pa (y)
National Tube Div., U.S. Steel Corp., Pa (ee)
New England Tape Co., Inc., Mass (dd)
Olin Mathieson Chemical Corp., Packaging Div., NY (t,ee)
Omni Products Corp., NY (y)
Ormond Mfg. Co., Inc., NJ (cc,dd)
Pacific Coast Foil Co., Calif (t)
Panelyte Div., St. Regis Paper Co., NY (t,cc,ee)
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Phillips Chemical Co., Okla (p)

Plastic Materials, Inc., NY (y)
Plastic Packaging Co., Ill (t)
Plax Corp., Conn (t,cc)
Polo Plastics Co., Wis (t)
Polyplastic Products, Inc., NJ (t,cc)
Precision Paper Tube Co., Ill (cc)
Presto Plastic Products Co., Inc., NY (t,cc)
Prince Rubber Co., Inc., NY (bb,cc,ee)
Pyramid Industries, Inc., Pa (ee)
Pyramid Plastics, Inc., Ill (dd,ee)
Reed Plastics Corp., Mass (y)
Reliance Plastic & Chemical Corp., NJ (t,bb,dd)
Reynolds Aluminum Supply Co., Ga (t)
Reynolds Metals Co., Va (t,cc)
Ross & Roberts, Inc., Conn (t)
Rubber & Plastics Compound Co., Inc., NY (t)
Russell Mfg. Co., Conn (s)
Schwab Plastic Corp., Mich (u,bb,cc,dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Seiberling Rubber Co., Plastics Div., Ohio (bb,cc)
Shaw-Kendall Engineering Co., Ohio (ee)
Sheller Mfg. Corp., Mich (u)
Shellmar-Betner Flexible Packaging Div., Continental Can Co., Inc., NY (t,cc)
Simon Products Co., Ill (t)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Spencer Chemical Co., Mo (p,x,y)
Staver Co., Inc., NY (cc,dd)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd,ee)
Supplex Co., Div. of Amerace Corp., NJ (y,dd,ee)
Technical Tape Corp., NY (t,cc,ee)
Thombert, Inc., Iowa (cc,ee)
Triangle Conduit & Cable Co., Inc., NJ (ee)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY (p,y)
U.S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp., NY (p,x,y)
U.S. Stoneware Co., NY (y)
Varflex Corp., NY (ee)
Visking Co., Plastics Div., Ind (t,cc)
Vogt Mfg. Corp., NY (bb,dd)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (s,bb,dd,ee)
Western Felt Works, Ill
(cc)
Western Plastics Corp., Neb (bb,dd,ee)
Western Plastics Corp., Wash (ee)
Westlake Plastics Co., Pa (t,bb,cc,dd,ee)
Woodall Industries, Inc., Mich (cc)
World Plastics, NY (bb,cc,dd,ee)

Polypropylene

AviSun Corp., Pa (y)
Chemore Corp., NY (y)
Enjay Co., Inc., NY
(y)
Hercules Powder Co., Del
(y)—Ad pp 264-265
Spencer Chemical Co., Mo (y)
Texas Eastman Co., Div. of Eastman Kodak Co., Tex (y)

Polystyrenes

(incl. copolymers and modifications)

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Ambassador Plastics & Mfg. Corp., Ill (u)
American Cyanamid Co., Plastics & Resins Div., NY
(y)
American Hard Rubber Co., Div. of Amerace Corp., NJ
(bb,cc,dd,ee)—Ad pp 240-241
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Anderson Asso., Inc., Ohio (y)
Anesit Co., Ill (ee)
Auburn Plastics, Inc., NY (bb,cc,dd,ee)
Bakelite Co., Div. of Union Carbide Corp., NY (p,y)
Bamberger, Claude P., Inc., NJ (p,y)
Blank, Arthur & Co., Inc., Mass (cc)
Cadillac Plastic & Chemical Co., Mich (x,bb,cc,dd,ee)
Campco Div., Chicago Molded Products Corp., Ill (t,cc)
Catalin Corp. of America, NY (y)
Chemical Development Corp., Mass (p)
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., Ill (bb,cc,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (y,bb,cc,dd)
Crescent Plastics, Inc., Ind (ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (bb,cc,ee)
Dapol Plastics, Inc., Mass (y)
Denver Plastics, Inc., Colo (u)
Dewey & Almy Chemical Co., Div. of W.R. Grace Co., Mass (p)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Dow Chemical Co., Plastics Div., Mich
(p,t,u,y)—Ad p 239
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y)
Dumont Corp., Calif
(u)
Dura Plastics of New York, Inc., NY (bb,cc)
Dyna-Therm Chemical Corp., Calif
(p)
Eclipse Plastic Industries, Inc., Fla (bb,cc,dd,ee)
Emerson & Cuming, Inc., Mass (u,x,bb)
Fiberfil, Inc., Ind (y)
Foster Grant Co., Mass (p,s,y,cc)
Fry Plastics Co., Calif (cc)
Galigher Co., Utah (bb,cc,dd,ee)
General Plastics Corp., Ind (cc)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Gering Products Inc., NJ (y,bb,dd)
Glass Laboratories, NY (bb,dd)
Glo-Brite Products, Inc., Ill (u,y,cc)
Goodyear Tire & Rubber Co., Ohio (y)
H & R Industries, Pa (bb,cc,dd,ee)
Haskelite Mfg Corp., Mich (u)
Hayden Wire Works, Inc., Mass (x)
Industrial Plastics Corp., Ind (bb,dd)
KSH Plastics Inc., Mo (bb,cc,dd)
Kaykor Industries, Inc., NJ (cc)
Koppers Co., Plastics Div., Pa
(p,u,y)—Ad pp 216-217
Laminated Plastex Corp., Ohio (x,cc)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc)
Maloney, F.H. Co., Tex (x,y)
Manufacturers Corp., Ohio (ee)
Marbon Chemical Div., Borg-Warner Corp., Ind
(p,y)
Midwest Plastic Products Co., Ill (t,cc)
Monsanto Chemical Co., Mass (p,y)
Muehlstein, H. & Co., Inc., NY (p,y)
Murray, A.B. Co., Inc., NJ (ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,y)
Nesbitt Industries, Inc., Ill (u)
Nixon Nitration Works, NJ (cc)
Northwest Plastics Industries, Inc., Wash (u)
Omni Products Corp., NY (y)
O'Sullivan Rubber Corp., Va (cc)
O'Sullivan Rubber Corp., Plastics Div., Va (t,cc)
Panelyte Div., St. Regis Paper Co., NY (u,bb,cc)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Plastic Materials, Inc., NY (y)
Plax Corp., Conn (t,cc)
Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa
(bb,cc)
Precision Paper Tube Co., Ill (ee)
Prince Rubber Co., Inc., NY (bb,cc,ee)
Pyramid Plastics, Inc., Ill (dd,ee)
Reed Plastics Corp., Mass (y)
Rex Corp., Mass (bb,cc)
Schwab Plastic Corp., Mich (u,bb,cc,dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Seiberling Rubber Co., Plastics Div., Ohio (bb,cc)
Sheller Mfg. Corp., Mich (u)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Strick Plastics Co., Pa (u)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd,ee)
Toyad Corp., Pa (u)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY (p,y)
United Shoe Machinery Corp., Mass (p,u)
Western Felt Works, Ill
(cc)
Western Plastics Corp., Neb (bb,dd,ee)
Western Plastics Corp., Wash (ee)
Westlake Plastics Co., Pa (t,y,bb,cc,dd,ee)
Woodall Industries, Inc., Mich (cc)
World Plastex, NY (bb,cc,dd)
World Plastics, NY (bb,cc,dd,ee)

Polysulfide Rubber

Adhesive Products Corp., NY (x)
Allis Rubber Div., Chicago-Allis Mfg. Corp., Ill (p)
Aries Laboratories, Inc., NY (p)
Armstrong Cork Co., Pa (bb,cc,dd)
Belko Corp., Md (y)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (x,y)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Garlock Packing Co., NY (y,cc)
Home Rubber Co., NJ (y,bb,cc,dd)
Maloney, F.H. Co., Tex (y)
Moxness Products, Inc., Wis
(bb,cc,dd,ee)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Parker, Stearns & Co., Inc., NY (y,bb,cc,dd,ee)
Polymer Industries Inc., Conn (x)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn
(x)
Thiokol Chemical Corp., NJ (p,x,y)
Trostel, Albert Packing, Ltd., Wis (y)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill
(y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill
(y,bb,cc,dd,ee)

Polyvinyl Alcohols

(see Vinyls)

Polyvinyl Chloride and Copolymers

(see Vinyls)

Porcelain

(see Ceramics)

Porcelain Enamels

(see Inorganic Coatings)

Powdered Metals

(see Iron Powders or specific metal)

Precoated Metals—Aluminized

American Chain & Cable Co., Pa (g)
Armco Steel Corp., Ohio (g)
Bethlehem Steel Co., Pa (g)
Biersach & Niedermeyer Co., Wis (a)
Brasco Mfg. Co., Ill (g)
Clad-Rex Corp., Ill
(a,g)
Colonial Alloys Co., Pa. (a)
Enamel Products Co., Ohio (g)
Gillett & Eaton, Inc., Minn (c)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Grigoleit Co., Ill (a)
Ideal Can Co., Mass (g)
Jackson Steel Products, Inc., NY (g)
Kees, F.D. Mfg. Co., Neb (g)
Mayville Metal Products Co., Wis (g)
National Galvanizing Co., Pa (g)
Olin-Mathieson Chemical Corp., Aluminum Div., NY (a)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (g)
Sun Steel Co., Ill (g)
Tickle, Arthur Engineering Works, Inc., NY (c,g)
Whitehead Metal Products Co., Inc., NY (g)
Whyte, Oliver Co., Inc., Mass (g)

Precoated Metals—Galvanized

Albert Pipe Supply Co., Inc., NY (g)
Anderson-Bolling Mfg. Co., Mich (g)
Armco Steel Corp., Ohio (g)
Associated Spring Corp., Wallace Barnes Div., Conn (g)
Atlantic Steel Co., Ga (g)
Bethlehem Steel Co., Pa (c,g)
Biersach & Niedermeyer Co., Wis (g)
Bignall Co., NY (c)
Brasco Mfg. Co., Ill (g)
Brewer-Titchener, Corp., NY (g)
Byers, A.M. Co., Pa (c)
Castle, A.M. & Co., Ill (a,g)
Clad-Rex Corp., Ill (g)
Columbia - Geneva Steel Div., U.S. Steel Corp., Calif (g)
Conner Mfg. Co., Ky (g)
Continental Nu-Steel Metal Products Div., Continental Wire & Iron Works, Ill (g)
Continental Steel Works, Corp., Ind (g)
Edgecomb Steel & Aluminum Corp., NJ (g)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Enterprise Galvanizing Co., Pa (g)
Grand Sheet Metal Products Co., Consumer Products Div., Ill (c)
Granite City Steel Co., Ill (g)
Hobbs, Clinton E. Co., Mass (c,g)
Ideal Can Co., Mass (g)
Jackson Steel Products, Inc., NY (g)
Kelley Mfg. Co., Tex (g)
Koehler Mfg. Co., Mass (c,g)
Kroh Wagner, Ill (g)
Levinson Steel Co., Pa (g)
Mahon, R.C. Co., Mich (g)
Mayville Metal Products Co., Wis (g)
McNally Pittsburg Mfg. Co., Kan (g)
Metal Goods Corp., Tex (g)
National Galvanizing Co., Pa (g)
National Tube Div., U.S. Steel Corp., Pa (g)
New York Iron Roofing & Corrugating Co., Inc., NJ (g)
Newport Steel Corp., Ky (g)
Nikoh Tube Co., Ill (g)
Northwestern Steel & Wire Co., Ill (g)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (g)
Republic Steel Corp., Ohio (g)—Ad pp 82-83
Riverside Foundry & Galvanizing Co., Mich (c,g)—Ad p 78-9
Roebling's, John A. Sons Corp., NJ (g)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Sharon Steel Corp., Pa (g)
Sherman & Reilly, Inc., Tenn (e,f,g)
Solar Steel Corp., Ohio (g)
Southern Galvanizing Co., Md (g)
Southern Metal Products Co., La (g)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio (g)—Ad pp 94-95
Stenman, Bror F., Mass (g)
Sun Steel Co., Ill (g)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Thomas Strip Div., Pittsburgh Steel Co., Pa (g)
U. S. Steel Corp. Pa (g)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
Vulcan Rail & Construction Co., NY (g)
Weirton Steel Co., Div. of National Steel Corp., W.Va (g)—Ad p 89
Wesbar Stamping Corp., Wis (c,g)
Wheeling Steel Corp., W.Va (g)
Witt Cornice Co., Galvanizing Div., Ohio (g)
Worcester Wire Works Div., National-Standard Co., Mass (g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Sheet & Tube Co., Ohio (g)

Precoated Metals—Lead or Terne-Coated

Acme Stamping & Mfg. Co., Pa (a, b,g)
Anderson-Bolling Mfg. Co., Mich (g)
Armco Steel Corp., Ohio (c,g)
Biersach & Niedermeyer Co., Wis (g)
Brasco Mfg. Co., Ill (g)
Cartwright, R. Tube Products Co., Mich (g)
Caspers Tin Plate Co., Ill (g)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (b)
Columbia - Geneva Steel Div., U.S. Steel Corp., Calif (g)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Follansbee Steel Corp., Sheet Metal Specialty Div., W.Va (g)
Hayden Wire Works, Inc., Mass (d)
Higbie Mfg. Co., Mich (g)
Houston Blow Pipe & Sheet Metal Works, Tex (g)
Ideal Can Co., Mass (g)
Langsenkamp, F.H. Co., Ind (b)
Mallory-Sharon Metals Corp., Ohio (g)
Metal Goods Corp., Tex (b)
National Lead Construction Co., Inc., NJ (d)
New Haven Copper Co., Conn (b)
Nikoh Tube Co., Ill (g)
Philadelphia Steel & Wire Corp., Pa (g)
Presswork, Inc., Mich (b,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (b)
Ryerson, Joseph T. & Son, Inc., (g)
Sandvik Steel, Inc., NJ (g)
Sharon Steel Corp. Pa (g)
Solar Steel Corp., Ohio (g)
Steel Protection & Chemical Co., Ind (a,b,c,f,g)
Sun Steel Co., Ill (g)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Thomas Strip Div., Pittsburgh Steel Co., Pa (g)—Ad pp 74-5
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
Wayne Foundry & Stamping Co., Mich (g)
Weirton Steel Co., Div. of National Steel Corp., W.Va (g)
Wesbar Stamping Corp., Wis (c,g)
Wheeling Steel Corp., W.Va (g)
Whitehead Metal Products Co., Inc., NY (b,g)
Wisconsin Tool & Stamping Co., Ill (g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)

Precoated Metals—Tin-Coated

Acme Stamping & Mfg. Co., Pa (a,b,g)
American Silver Co., NY (a,b,e,f,g)
Anderson-Bolling Mfg. Co., Mich (g)
Association Spring Corp., Wallace Barnes Steel Div., Conn (g)
Bethlehem Steel Co., Pa (g)
Brasco Mfg. Co., Ill (g)
Caspers Tin Plate Co., Ill (g)
Columbia - Geneva Steel Div., U.S. Steel Corp., Calif (g)
Conner Mfg. Co., Ky (g)
Granite City Steel Co., Ill (g)
Inland Steel Co., Ill (g)
Kaiser Steel Corp., Calif (g)
Koehler Mfg. Co., Mass (c,g)
Lundquist Tool & Mfg. Co., Inc., Mass (a,g)
Olean Electro Plating Co., NY
Philadelphia Steel & Wire Corp., Pa (g)
Republic Steel Corp., Ohio (g)
Riverside Foundry Co., Pa (c)
Smithers Tool & Machine Products, Inc., NY (g)
Solar Steel Corp., Ohio (g)
Somers Brass Co. Inc., Conn (b,f)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio (g)—Ad pp 94-95
Steel Protection & Chemical Co., Ind (a,b,c,f,g)
Sun Steel Co., Ill (g)
U. S. Steel Corp., Pa (g)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Wabash Metal Products Co., Inc., Ind (g)
Weirton Steel Co., Div. of National Steel Corp., W.Va (g)
Wheeling Steel Corp., W.Va (g)
Wisconsin Tool & Stamping Co., Ill (g)
Youngstown Sheet & Tube Co., Ohio (g)

Pre-Impregnated Materials for Plastic Laminates

American Plastics Corp., NY (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Coast Mfg. & Supply Co., Calif (l)—Ad p 293
Cordo Chemical Corp., Conn (k,l,m)
Cordo Molding Products, Inc., NY (l)—Ad p 262
Eljay Corp., Md (k,l)
Emerson & Cuming, Inc., Mass (k,l,m)
Fabricon Products Div., Eagle-Picher Co., Mich (l)—Ad p 255
Flexfirm Products, Calif (k,l)
Flexible Tubing Corp., Conn (k)
Haveg Industries Inc., Del (l)
Luminous Resins Inc., Ill (k)
Maloney, F.H. Co., Tex (l)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Minnesota Mining & Mfg. Co., Minn (l)
Modiglass Fibers, Inc., NJ (k,l)
Narmco Resins & Coating Co., Calif (l)
New England Laminates Co., Conn (l)
Panelyte Div., St. Regis Paper Co NY (l)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (l)
Riegel Paper Corp., NY (k,l)
Rogers Corp., Conn (l)
Russell Mfg. Co., Conn (l)
Spaulding Fibre Co., Inc., NY (l)
Standard Insulation Co., Plastics Div., NJ (l)
Sun Chemical Corp., Electro Technical Div., (k,l,m)
Swedlow Plastics Corp., Ohio (l)
U.S. Polymeric Chemicals, Inc., Conn (k,m)

Prepainted Metals

(see Organic Coatings)

Preplated Metals

(chromium, nickel)

Aluminum Co. of America, Pa (a)
American Nickeloid Co., Ill (a,b,g,j)
American Silver Co., Inc., NY (b,f,g)
Apollo Metal Works, Ill (b,c,g,j)
Benjamin Electric Mfg. Co., Ill (g)
Chromalloy Corp., NY (g)
Enamelstrip Corp., Sub. of National Steel Corp., Pa (a,b,c,f,g,h,j)
Fromson Orban Co., Inc., NY (a)
Grand Sheet Metal Products Co., Consumer Products Div., Ill (a,b,c, e,f,g,h,j)
Grigoleit Co., Ill (a,g)
Hayden Wire Works, Inc., Mass (a,b, f,j)
Kroh Wagner, Ill (a,g)
Mechanical Steel Tubing Corp., NY (g)
Metal Trims, Inc., Miss (a)
Republic Steel Corp., Ohio (g)
Rigidized Metals Corp., NY (a,g)
Roebling's, John A. Sons Corp., NJ (g)
Sun Steel Co., Ill (g)
Sylvania Electric Products, Inc., Parts Div., Pa (a,b,c,f,g)
Thomas Strip Div., Pittsburgh Steel Co., Pa (b,f,j)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (g)
Worcester Wire Works Div., National-Standard Co., Mass (g)

Pressure Sensitive Tapes

(see tapes)

Protein Plastics

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)
American Plastics Corp., NY (bb,cc)
Borden Co., Chemical Div., NY (p)
Chemical Process Co., Calif (x)
National Casein Sales, Ill (p)
Reichhold Chemicals, Inc., NY (p)

Quartz

(see Ceramics)

Refractories

Baxter Foundry & Machine Works, Inc., Id (r)
Carborundum Co., NY (r,z,bb,ee)
Carborundum Co., Refractories Div., NJ (r)
Cedar Heights Clay Co., Ohio (aa)
Commercialores, Inc., SC (aa)
Continental Coatings Corp., Ohio (aa)
Coors Porcelain Co., Colo (r,z,bb,cc,ee)

Corning Glass Works, NY
(r)
Dixon, Joseph Crucible Co., NJ (r)
Du-Co Ceramics Co., Pa (r,z,aa,bb,ee)
Dyna-Therm Chemical Corp., Calif
(r,s)
Electrical Refractories Co., Ohio (r, bb,ee)
Electro Refractories & Abrasives Corp., NY (r)
Emerson & Cuming, Inc., Mass (r)
Ferro Corp., Ohio (aa)
Foote Mineral Co., Pa (aa)
France, J.H. Refractories Co., Pa (r)
General Ceramics Corp., NJ (r)
General Refractories Co., Pa (r)
Gladding, McBean & Co., Calif (r)
Green, A.P. Fire Brick Co., Mo (r,s)
Haws Refractories Co., Pa (r)
Ironton Fire Brick Co., Ohio (r)
Laboratory Equipment Corp., Mich (r)
Louthan Mfg. Co., Div. of Ferro Corp., Ohio (r,z,bb,cc,ee)
Malvern Brick & Tile Co., Ark (r)
McCrady Refractories, Inc., Pa (aa)
Morganite, Inc., NY (r,ee)
North American Refractories Co., Ohio (r)
Norton Co., Mass
(r,aa,ee)—Ad p 287
Porter, H.K. Co., Inc., Refractories Div., Pa (r)
Refractory & Insulation Corp., NY (r,aa)
Refractory Specialties Co., Pa (r,y)
Sauereisen Cements Co., Pa (aa)
Shenango Refractories, Pa (r,z)
Star Porcelain Co., NJ (r,z,bb,ee)
Sylvester & Co., Ohio (r)
Thermal Refractories Corp., NJ (r, z,bb,cc,ee)
Thompson, H. I. Fiber Glass Co., Calif
(s)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
(aa)
U.S. Graphite Co., Div. of Wickes Corp., Mich (aa)
Universal-Cyclops Steel Corp., Pa (r)
Wellsville Fire Brick Co., Mo (r)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (r)
Zirconium Corp. of America, Ohio (r, aa,bb,ee)

Reinforced Plastics

(see Laminates)

Rhenium

Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (aa, bb,dd,ff)
Hardy, Charles, Inc., NY (aa)
Mallory, P.R. & Co., Inc., Ind (bb)
Nuclear Metals, Inc., Mass (w,bb)
University of Tennessee, Dept of Chemistry, Tenn (aa)

Rock Wool

(see Inorganic Fibers)

Rod

(see specific material)

Rods, Welding

(see Filler Metals)

Roll Formed Parts

A & A Die Casting Co., Calif (a,b,g)
Abalon Precision Mfg. Corp., NY (a, b,c,g)
Acme Tube, Inc., NJ (a,b,c,g)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (g)
Alloy Products Corp., Wis
(a,f,g,h)—Ad p 408
Aluminum Co. of America, Pa (a)
American Brass Co., Sub. of Anaconda Co., NY
(b)
American Car & Foundry Div., ACF Industries, Inc., NY (a,e,g)
American Nickel Alloy Mfg. Corp., NY (f)
American Pipe & Construction Co., Northwest Div., Ore (g)
Ampco Metal, Inc., Wis (b)
Arrow Metal Products Corp., NJ (a)
Beck, I. & Sons, Inc., NY (a,b,g)
Biersach & Niedermeyer Co., Wis (a, b,c,g)
Brush Beryllium Co., Ohio
(b)
Bunker Hill Co., Calif (d)
Burkhardt Steel Co., Colo (c,g)
Byers, A.M. Co., Pa (c)
Carbo Tool & Die Co., Ohio (c)
Carpenter Steel Co., Pa (g)
Chicago Screw Co., Div. of Standard Screw Co., Ill (a,b,c,f,g)
Craft Mfg. Co., Ill (f,g)
Crucible Steel Co. of America, Pa
(g,h)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (h)
Dahlin, C.A. Co., Ill (a,b,f,g,j)
Day Co., Minn (a,g)
Division Lead Co., Ill (d)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Dresser Mfg. Div., Dresser Industries, Inc., Pa (a,f,g,h)
Eaton Mfg. Co., Reliance Div., Ohio (g)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a, b,f,g)
Enamel Products Co., Ohio (c)
Fabristeel Products, Inc., Mich (g)
Falstrom Co., NJ (a,b,e,g,h)
Fitzgibbons Boiler Co., Inc., NY (c)
Fletcher Enamel Co., W. Va (a,b,c,d,e, f,g)
Grigoleit Co., Ill (a,g)
Ideal Can Co., Mass (a,b,g)
Inland Steel Co., Ill (g)
Irwin-Sensenich Corp., Pa (g)
Jackson Steel Products, Inc., NY (a, b,f,g,j)
Kaiser Steel Corp., Calif (g)
Kelley Mfg. Co., Tex (a,b,g)
Kelsey-Hayes Co., Mich (g)
Kroh Wagner, Ill (a,b,c,f,g,j)
Leach & Garner Co., Industrial Div., Mass (b,f)
Lock Joint Tube Co., Inc., Ind (g)
Magnesium Co. of America, Ind (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,c,e,f,g,h)
Manufacturers & Fabricators, Inc., Ohio (f,g)
McLanahan & Stone Corp., Pa (g)
Mechanical Steel Tubing Corp., NY (a, g)
Merrimac Brass, Mass (b,f)
Metal Forming Corp., Div. of Vanadium-Alloys Steel Co., Ind (a,c,f,g)
Midvale-Heppenstall Co., Pa (c,f,g)
Mirro Aluminum Co., Wis (a)
Morse, Fred W. Co., RI (a,b,c,g,j)
National Aluminum Co., Ohio (a,g)
National Metal Products Co., Pa (a, b,g,j)
National Screw & Mfg. Co., Ohio (b,g)
Nikoh Tube Co., Ill (g)
Nippert Electric Products Co., Ohio (b)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Pfister Aluminum Corp., NJ (a)
Posey Iron Works, Inc., Pa (g)
Pyramid Mouldings, Inc., Ill (a,b,c,g)
Regal Ware, Inc., Wis (a,b,g)
Revere Copper & Brass, Inc., Ill (a,b, c,f,g,j)
Reynolds Aluminum Supply Co., Ga (a)
Rockwell - Standard Corp., Bossert Stamping Div., NY
(a,b,c,f,g)
Roll Formed Products Co.. Ohio
(a,b,e,g)—Ad p 413
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Security Cos., Mich (a)
Security Sash & Screen Co., Mich (a)
Serrick Corp., John Lees Div., Ind (a,g)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio
(g)
Standard Pressed Steel Co., Pa (b,g)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (g)
Stanwood Corp., Ill (g)
Sylvania Electric Products, Inc., Parts Div., Pa
(b,f,g)
Textron Metals Co., Ohio (a)
Thompson Pipe & Steel Co., Colo (a,b, c,d,e,f,g)
U.S. Graphite Co., Div. of Wickes Corp., Mich (aa)
Vulcan Mfg. Co., Ohio (a,b,c,f,g)
Wal-Mar Corp., Ill (a,b,c,e,g)
Werner, R.D. Co., Inc., NY (a,b,g,j)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (a,b,c,f,g)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (a,b,c,e,f,g)
Wyatt Metal & Boiler Works, Inc., Tex (a,b,c,e,f,g)

Rubber, Natural

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NY
(bb,cc,dd)—Ad pp 240-241
American Rubber Products Corp., Ind (u,bb,cc,dd,ee)
Atlas Mineral Products Co., Pa (cc)
Auburn Rubber Co., Inc., Ind (cc)
Automotive Rubber Co., Inc., Mich (cc, dd)
Belko Corp., Md (y)
Brown Rubber Co., Inc., Ind (u)
Capac Mfg. Corp., Mich (y,cc)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Colonial Rubber Co., Div. of U.S. Stoneware Co., Ohio (y)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Coyne & Paddock, Inc., NY (cc)
Dayton Rubber Co., Ohio (u,y,bb,cc,dd, ee)
Douglas & Sturgess, Calif (x,y)
Johns-Manville Corp., Dutch Brand Div., Ill (u,y,cc,dd)
Faultless Rubber Co., Ohio (u,y,bb,ee)
Flexible Tubing Corp., Conn (ee)
Foam Products, Inc., Pa (u)
Foamade Industries, Mich (u)
Garlock Packing Co., NY (y,bb,cc,dd, ee)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Chemical Co., Sponge Products Div., Conn (u)
Goshen Rubber Co., Inc., Ind
(y)
Hardman, H.V. Co., Inc., NJ (x)
Hayes Adhesive Co., Inc., Mo (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Johns-Manville Corp., NY (cc)
Luzerne Rubber Co., NJ (bb,cc,dd,ee)
Maloney, F.H. Co., Tex (y)
Martin Rubber Co., Inc., NJ (y,dd,eee)
Mid-States Rubber Products, Inc., Ind (y)
Morningstar-Paisley, Inc., NY (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
Paeco Rubber Co., Inc., Ohio (y)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Polymer Chemical Co., Ohio (x,y)
Prince Rubber Co., Inc., NY (cc,ee)
Rand Rubber Co., NY (p,t,cc)
Raybestos-Manhattan, Inc., NJ (bb, cc,dd)

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v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Raybestos - Manhattan, Inc., Plastic Products Div., Conn
(x)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,bb,cc,dd,ee)
Rogers Corp., Conn (y,cc,dd)
Roth Rubber Co., Ill
(y,cc)
Rubatex Div., Great American Industries, Inc., Va (u)
Rubber Corp. of America, NY (u)
Russell Mfg. Co., Conn (s)
Sheller Mfg. Corp., Mich (u)
Snyder, M.L. & Son, Inc., Pa (ee)
Standard Products Co., Mich (y)
Stockwell Rubber Co., Inc., Pa (u,y, bb,cc,dd)
Technical Specialties Co., NY (dd)
Toyad Corp., Pa (t,u)
Trostel, Albert Packing, Ltd., Wis (y)
U.S. Rubber Co., Kem-Blo Dept., Conn (u)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill
(y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill
(y,bb,cc,dd,ee)

Rubber, Synthetic

(see specific material)

Sand Casting

(see Castings)

Sandwich Materials

(key letters refer to core materials)

Allegheny Ludlum Steel Corp., Pa
(g)
Almco Steel Products Corp., Ind (g)
Aluminum Co. of America, Pa (a)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Artmor Plastics Corp., Md (l)
Bar-Ray Products, NY (d)
Bridgeport Brass Co., Conn
(g)
Brunswick-Balke-Collender Co., Defense Products Div., Mich (a,l)
Busch, J.C. Co., NY (a,c)
Cadillac Plastic & Chemical Co., Mich (l)
Continental Rubber Works, Pa (m)
Dow Chemical Corp., Plastics Div., Mich
(k)
Douglas Aircraft Co., Inc., Aircomb Div., Calif (l)
Dumont Corp., Calif
(a,k,m)—Ad p 410
General Findings & Supply Co., Industrial Div., Mass (b,f)
General Tire & Rubber Co., Ind (l)
Glo-Brite Products, Inc., Ill (l)
H & R Industries, Pa (k)
Hardy Mfg. Corp., Ind (g)
Haskelite Mfg. Corp., Mich (k,l,m)
Hawkeye Rubber Mfg. Co., Iowa (g,m)
Hexcel Products, Inc., Calif (a,g)
Leach & Garner Co., Industrial Div., Mass (b,f)
Lukens Steel Co., Pa
(a,b,e,f,g,h)
Luminous Resins, Inc., Ill (k)
Lunn Laminates, Inc., NY (l)
Mechanical Rubber Products Co., NY (l)
Minnesota Mining & Mfg. Co., Minn (l)
National Moldite Co., NJ (c)
National Vulcanized Fibre Co., Del (l)
Northwest Plastics Industries, Inc., Wash (l)
Nuclear Metals, Inc., Mass (a,b,c,e,f, g,h)
Permal, Inc., NJ (l)
Presswork, Inc., Mich (b)
Replac Corp., Ohio (k,l,m)
Rogers Corp., Conn (l,m)
Russell Mfg. Co., Conn (b)
Russell Reinforced Plastics Corp., NY (l)
Solar Aircraft Co., Calif (g,h)
Standard Insulation Co., NJ (l)
Standard Metals Corp., Mass (c,f)
Superior Steel Div., Copperweld Steel Co., Pa (g)
Swedlow, Inc., Calif (a,f,g,h)
Thermoid Div., H.K. Porter Co., Pa (l)
Thompson, H. I. Fiber Glass Co., Calif
(k)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY
(aa)
West Haven Foundry Co., Conn (a,b)
Wittman, Lawrence & Co., NY (l)
Zenith Plastics Co., Calif (l)

Screw Machine Parts

Abalon Precision Mfg. Corp., NY (a, b,c,g)
Abbott Products, Inc., NY (a,b,c,d,e, f,g,h,j)
Advance Screw Products Co., Inc., Wis (a,b,c,g)
Aero Screw Co., Inc., Wis (b,c,f,g)
Affiliated Screw Products Co., Ill (a, b,c,d,e,f,g,h,j)
Aircraft Screw Machine Products Co., Ill (a,b,f,g)
Albany Products Co., Inc., Conn. (b,f)
Allied Machine Products Co., Mich (a,b,g)
Allied Metal Products Co., Mass (a, b,c,g)
Allied Products Corp., Mich (g)
Allmetal Screw Products Co., Inc., NY (f,g,h)
Aluminum Co. of America, Pa (a)
American Electrical Products Co., Ohio (a,b,f,g)
American Fabricated Products Co., Ind (a,b,f,g)
American Sanitary Mfg. Co., Ill (b)
American Screw Products Co., Mich (a,b,g)
Ampco Metal, Inc., Wis (b)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Approved Mfg. Co., Inc., Mich (b,g)
Argosy Products, Inc., Ohio (a,b,g)
Ashby Mfg. Co., Mo (b,f,g)
Atkins Saw Div., Borg-Warner Corp., Ind (g)
Auburn Spark Plug Co., Inc., NY (a, b,c,d,f,g,h)
Auel Industries, Pa (a,b,g)
Autel Electronics Co., Precision Machine & Welding Div., NJ (a,b,c,e, g,h)
Automatic Metal Products Corp., Mich (b,f,g,h)
Babson Dow Mfg. Co., Mass (a,b,c, f,g)
Balas Collet Mfg. Co., Ohio (a,b,f,g)
Baldwin Mfg. Co., Conn (a,b,c,d,f, g,h,j)
Barton Products Corp., Wis (a,b,c,e, f,g)
Bayley Products, Inc., Mich (a,b,g)
Beacon Metal Mfg. Co., NY (a,b,c,e, f,g,h,j)
Beck Products Corp., Mich (a,b,f,g)
Bell, David Co., Inc., NY (a,b,f,g,h)
Bethandale Corp., Ohio (a,b,f,g)
Bickford, F.H. Co., Ohio (a,b,g)
Biddle Screw Products Co., Ind (a,b, c,d,e,f,g,h)
Blacher Bros., Inc., RI (a,b,g)
Boehm Screw Products Co., Mich (a, b,f,g)
Boots Aircraft Nut Corp., Conn (a, b,f,g)
Brown Corp., NY (g)
Buchmann Spark Wheel Corp., NY (a, b,c,e,f,g)
Buckeye Brass & Mfg. Co., Ohio (b)
Burgess-Norton Mfg. Co., Ill (c)
C & G Screw Machine Products Co., Ind (a,b,g)
Carleton Screw Products Co., Minn (a, b,g)
Cartwright, R. Tube Products Co., Mich (a,b,g)
Central Screw Products Co., Mich (a, b,f,g)
Chapman Machine Co., Inc., Conn (a, b,f,g)
Chardon Metal Products Co., Ohio (a, b,f,g)
Chicago Screw Co., Div. of Standard Screw Co., Ill (a,b,c,f,g)
Clendenin Bros., Inc., Md (b)
Cleveland Cap Screw Co., Ohio (a,b, f,g,h)
Cleveland City Forge Co., Ohio (c,g)
Collis Co., Iowa (a,b,f,g)
Columbus Dental Mfg. Co., Ohio (a, b,c,g)
Columbus Jack Corp., Ohio (a,c,g)
Columbus Production Mfg. Co., Ohio (a,b,g)
Comerford Mfg. Co., Inc., Conn (a,b, c,e,f,g,h,j)
Condamatic Co., Inc., Mich (a,g,h)
Conn Perry Mfg. Co., Mich (b,g)
Connecticut Mfg. Co., Conn (b,f,g)
Control Parts Corp., NY (a,b,c,d,e,f, g,h,j)
Couch-Uthe Co., Ohio (b,f,g)
Curtis Products Co., Conn (a,b,c,f,g)
Curtis Screw Co., Inc., NY (a,b,f,g,h)
Davis & Hemphill, Md (a,b,c)
Dawlen Corp., Mich (a,b,c,f)
Decatur Automatic Screw Machine Products Co., Ill (a,b,f,g)
Deerfield Mfg. Co., Ohio (a,b,f,g)
Defiance Screw Machine Products Div., Serrick Corp., Ohio (g)
Delo Screw Products Co., Ohio (a, b,f,g)
Dependable Automatic Screw Co., Conn (a,b,c,d,e,f,g,h,j)
Dixon Corp., RI (k)
Drexel Screw Products Co., Ill (a,b, c,d,f,g,k)
Duffin Mfg. Co., Ohio (a,b,g,h)
Duro Screw & Mfg. Co., NJ (a,b, f,g,h)
Eastern Machine & Screw Corp., Conn (a,g)
Economy Machine Products Co., Ill (a,b,f,g)
Electric Auto-Lite Co., Ohio (a,b,c,g)
Electric Materials Co., Pa (b)
Electronic Parts Mfg. Co., NJ (c,g)
Elsby, J.S., Inc., Wis (a,b,f,g)
Enoch Mfg. Co., Ore (a,b,c,e,g,j)
Essential Bar Products Co., Mich (a, b,f,g)
Eureka Electric Products Co., Pa (a,b)
Everard Tap & Die Corp., NY (a,b,c, f,g)
Fairchild Screw Products, Inc., Conn (a,b,f,g)
Falls Machine Co., Ohio (a,b,g)
Federal Screw Works, Mich (a,b,f,g)
Femco Mfg. Co., Inc., Mich (g)
Fischer Special Mfg. Co., Ohio (a,b)
Fordsell Machine Products Co., Mich (b,f,g)
Frisby, R.J. Mfg. Co., Ill (a,b,g)
G & G Mfg. Co., Ill (a,b,f,g)
G & Z Automatic Products Co., Mich (a,b,g)
Gantner Screw Products Co., Inc., Ohio (a,b,f,g)
General Engineering Works, Ill (a,b,f, g)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
General Screw Products Corp., NY (a, b,f,g)
Grass, M.J. Machine Products Co., NY (a,b,f,g)
Greer Stop Nut Co., Ill (a,b,c,e,f,g,h, j)
Gregg Metal Products Inc., Wis (a,b, f,g)
Gross Willard N., Inc., NJ (a,b,f,g)
H & H Screw Products, Inc., NY (a, b,f,g,h)
H & H Screw Products Mfg. Co., RI (a,b,f,g)
H & K Machine Service Co., Inc., Mo (a,b,g)
Haber, Ill (a,b,c,f)
Hack, J.H. Mfg. Co., Mich (a,b,f,g)
Hardy Mfg. Corp., Ind (a,b,g)
Harvey Aluminum Sales, Inc., Calif (a,g)
Harvin & Co., NJ (a,b,f,g)
Harwood Screw Products, Inc., Ohio (a,b,g)
Held, O.P., Inc., NY (a,b,c,g)
Heller, A.B. Screw Products, Inc., Mich (a,b,g)
Henefelt Precision Products, Ohio (a, b,f,g)
Hercules Fastener Co., Ill (a,c,f,g,j)
Herker Screw Products, Inc., Wis (a,b, g)
Herman Machine & Tool Co., Ohio (a, b,f,g)
Hershey Metal Products, Inc., Conn (a,b,f,g,h)
Holt Products Co., Mich (a,g)
Hoofer Mfg. Co., Ill (a,c)
Hoyt, Charles D. Co., Inc., Ind (a, b,f,g)
Huck Mfg. Co., Mich (a)
Hudson Screw Machine Products Co., Ill (a,b,c,e,f,g,h,j)
Hunt Screw & Mfg. Co., Ill (a,b,f,g,h)
Huron Automatic Screw Co., Mich (a,b,g)
Hy-Level Screw Products Co., Ohio (a, b,g)
Ideal Metal Products Co., Ill (a,b,f,g)
Imsande Screw Products Co., Ohio (a, b)
Industrial Precision Products, Ill (a,b, c)
Industrial Screw Machine Products Co., Ill (a,b,f,g)
Inland Mfg. Co., Neb (a,b,c,d,e,f,g,h,j)
Instrument Parts Corp., NY (a,b,c,f,g)
Instrument Specialties Co., Inc., NJ
(b)—Ad p 381
Jaques Co., Mass (a,b,e,f,g,h)
Jolens Metal Products Co., NJ (a,b,f, g)
Jordan Machine Products, Inc., Mich (a,b,f,g)
Kay-Bee Machine Products Co., Wis (a,b,g)
Kennedy Automatic Products, Inc., Mich (a,b,g)
Kenosha Automatic Products Co., Wis (a,b,g)
Kerr-Lakeside Industries, Inc., Ohio (a,b,f,g)
Kewaunee Engineering Corp., Wis (c)
Klincher Locknut Corp., Ind (a,b,c,f,g)
Koehler Mfg. Co., Mass (c)
Kohn Engineering Corp., Mich (a,b,c, f,g,h)
Kramer, C.P. Co., Ill (a,f,g)
Lake Mfg. Corp., Conn (a,b,g)
Lamson Products Co., Wash (a,b,d,e, f,g,j)
Lattner Bros. Machining Co., Mich (a, b,f,g)
Latwaitis, Ernest A., NY (a,b,f,g)
Lawrenceville Screw Co., Pa (a,b,f,g)
Lincoln Machine Parts Corp., NY (a, b,f,g,h)

Lincoln Mfg. Co., Inc., Ill (a,b,f,g)
Linden & Co., Inc., RI (a,b,c,g)
Livingston-Tyler Products, Ohio (a,b,e,g)
Locke Machine Co., Ohio (a,g)
Loeffler, J.M. Co., Machine & Brass Works, Pa (a,b,c)
Lorain Automatic Screw Machine Co., Inc., Ohio (a,b,g)
Lubenow, Arthur Co., Wis (a,b,f,g)
Lundberg Screw Products Co., Mich (a,b,g)
Lyndon Machine Products Co., Inc., Mich (a,b,g)
M & S Mfg. Co., Mich (a,b,g)
Machine Products Corp., Ohio (a,b,c,d,e,f,g,h,j)
Machinery Products Co. of Lancaster, Pa (a,b,f,g)
Machinery Products Corp., Ill (a,b,f,g)
Mac-It Parts Co., Pa (b,f,g)
Main Screw Machine Products, Inc., Conn (a,b,g)
Mantel Screw Products Co., Wis (a,b,f,g,h)
Marquette Metal Products Co., Ohio (a,b,f,g)
Masco Screw Products Co., Mich (a,b,f,g)
Massachusetts Screw Mfg. Co., Mass (a,b,f,g)
Maynard Mfg. Co., Mich (a,b,f,g,h)
McKinney Mfg. Co., Pa (a,b,e,f,g)
McLanahan & Stone Corp., Pa (c,g)
McMahon Bros. Machine Works, Inc., Ill (a,b,f,g,h)
Meaden Screw Products Co., Ill (a,b,f,g)
Measuregraph Co., Mo (a,b,f,g,h)
Mechanical Art Works, Inc., NJ (a,b,f,g)
Meier Screw Products & Mfg. Co., Mich (a,b,c,e,f,g)
Merit Screw Machine Products Co., Ill (a,b,f,g,h)
Merit Specialties Co., Inc., Mo (a,b,e,f,g)
Merz Machine & Tool Works, Ind (a,b,g)
Micro Products Corp., Mo (a,g)
Mid-West Screw Products Co., Mo (a,b,c,g)
Midwest Screw Products, Inc., Ohio (a,b,f,g,h)
Milford Automatics, Inc., Conn (a,b,g)
Milled Screw Products, Co., Ill (a,b,f,g)
Millers' Brass Fitting Co., Inc., NY (a,b,f,g)
Milwaukee Machine Products Co., Wis (a,b,g)
Milwaukee Stamping Co., Wis (a,g)
Mitchell & Scott Machine Co., Inc., Ind (a,b,f,g)
Modern Screw Products Co., Mo (b,f,g)
Monarch Tool & Mfg. Co., Ky (g)
Moody Machine Products Co., Inc., RI (a,b,g)
Moore, George W., Inc., Mass (a,b,g)
Mueller Brass Co., Mich (a,b,f)—Ad p 397
Mueller Machine Products Inc., Wis (a,b,c,d,e,f,g,j)
Napoleon Products Co., Ohio (a,g)
National Acme Co., Ohio (a,b,f,g)
National Lead Co., NY (a)
National Screw & Mfg. Co., Ohio (b,f,g)
Naugatuck Automatics, Inc., Conn (a,b,g)
New Britain Machine Co., Conn (a,b,g)
New Haven Screw Machine Products, Inc., Conn (a,b,f,g,h,j)
Newtown Mfg. Co., Conn (a,b,f,g,h)
Nicoud Mfg. Co., Ill (a,b,f,g)
Noera Mfg. Co., Conn (a,b,g)
Nolte Screw Machine Products Co., Ohio (a,b,c,f,g)
Northwest Automatic Products Corp., Minn (a,b,f,g)
Northwestern Machine Corp., Mo (a,b,f,g)
Nutmeg Screw Machine Products Co., Conn (a,b,f,g)
Nylok Corp., NJ (a,b,c,e,g,h)
Ohio Metal Products Co., Ohio (a,b,f,g,h)
Ohio Screw Products, Inc., Ohio (a,b,f,g)
Olderman Mfg. Corp., Conn (a,b)
Olson Mfg. Co., Mass (a,b,f,g)
Ostby & Barton Co., Flightex Fabrics, Inc., RI (a,b,f,g)
Ottawa Steel Products, Inc., Mich (g)
Owen Mfg., Inc., Ill (a,b,f,g)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g,h,j)
Pacific Screw Products Co., Calif (a,b,f,g)
Pan-American Metal Products Co., Inc., Fla (a,b,f,g)
Parker & Harper Mfg. Co., Mass (a,b,f,g)
Peck Spring Co., Conn (a,b,c,f,g)
Peerless Automatic Machine Co., Ohio (a,b,c,g)
Peerless Industries, Inc., Mich (a,b,g)
Peerless Products Industries, Ill (a,b,g,k,l)
Perry Fay Co., Ohio (a,b,g)
Philadelphia Enameling Works Inc., Pa (a,b,g)
Phillips, F.C., Inc., Mass (b,f,g)
Phillips Bros. Screw Products Co., Mich (b,f,g,h)
Piper Tool Co., Inc., Mich (g)
Pohlman, R.L. Co., Mo (a,b,g)
Polyphase Machine Co., NY (a,b,f,g,h)
Precision Machine Co., Ind (a,b,g)
Precision Piece Parts, Inc., Ind (g)
Precision Screw Products Co., Inc., Calif (a,b,f,g)
Progressive Service Co., Mo (a,b,e,f,g)
Racine Screw Co., Wis (a,b,f,g)
Rainier Metal Products Co., Ill (a,b,g)
Rasco-Veeder Co., Ill (a,b,f,g)
Ravenswood Machine Corp., Ill (a,b,f,g)
Red Devil Mfg. Co., Ill (a,b,c,d,e,f,g,h,j)
Redmer Air Devices, Ala (a,b,c,f,g)
Reliable Screw Machine Products, Ill (a,b,f,g,h)
Remler Co., Ltd., Calif (a,b,f,g)
Rex Products Co., Ohio (a,b,f,g)
Richmond Mfg. Co., Tex (a,b,f,g)
Rosan Inc., Calif (a,g)
S & S Mfg. Co., NJ (a,b,c,e,f,g,h)
Sargent & Greenleaf, Inc., NY (a,b,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b)
Seltzer, George H. & Co., Pa (g)
Sharpsville Steel Fabricators, Inc., Pa (g)
Sheller Mfg. Corp., Mich (g)
Sinclair Co., Mass (a,b,g)
Skookum Co., Inc., Ore (g)
Spencer Nahm Co., Calif (a,b,f,g)
Spencer's Sons, I.S., Inc., Conn (a,b,g)
Standard Pressed Steel Co., Pa (a,b,c,e,f,g,h)
Standard Screw Products Co., Calif (a,b,g)
Star Heel Plate Co., Inc., NJ (g)
Steel Heddle Mfg. Co., Pa (a,b,c,e,f,g,h,j)
Steel Industries, Inc., Ind (a,b,g)
Steinen, Wm. Mfg. Co., NJ (a,b,c,f,g,h)
Thompson-Bremer & Co., Ill (a,b,c,f,g,h)
Thompson Products, Inc., Ohio (h)
Titan Metal Mfg. Co., Pa (a,b)—Ad p 388
Tompkins Products, Mich (a,b,c,d,f,g,j)
Trigon Specialties Corp., Ind (a,b,c,d,e,f,g,h,j)
Ullmann, Inc., Wis (a,b,c,e,f,g,h)
Union Screw & Mfg. Co., Pa (a,b,g)
United Screw & Bolt Corp., Ill (a,b,g)
United Shoe Machinery Corp., Mass (a,b,c,f,g)
Unity Machine & Tool Corp., Pa (a,g)
Vanamatic Co., Ohio (a,b,g)
Wagner Specialty Co., Wis (a,b,c,g,j)
Wall, P. Mfg. Co., Pa (a,b,c,g)
Walrod Machine Products, Ore (a,b,g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Waterman Industries, Inc., Calif (a,b)
Weatherhead Co., Ind (a,b,c,d,e,f,g,h,j)
Weber-Knapp Co., NY (a)
Wedler Bros., Inc., Ohio (a,b,f,g)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (a,b,c,f,g)
Western Machine Co., Wis (a,b,c,f,g,j)
Wirth, Carl & Son, Inc., NY (a,b,c,d,e,f,g,h,j)
Worth Co., Wis (a,b,c,g)
Wright, Albert Screw Machine Products, Calif (a,b,f,g)
Wuest Bros., Inc., Ky (a,b,c,f,g)
Zeller Corp., Ohio (g)

Selenium

American Metal Climax, Inc., NY (aa)
American Nickel Alloy Mfg. Corp., NY (aa)
American Smelting & Refining Co., NY (q,aa)
Anaconda Co., NY (aa)
Belmont Smelting & Refining Works, Inc., NY (aa)
Cerro de Pasco Sales Corp., NY (aa)
Federated Metals Div., American Smelting & Refining Co., NY (aa)
Hardy, Charles, Inc., NY (aa)
Hommel, O. Co., Pa (aa)
Kawecki Chemical Co., NY (aa)
McGean Chemical Co., Ohio (aa)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Phelps Dodge Refining Corp., NY (aa)

Sheet

(see specific material)

Sheet Formed Plastics Parts

(see Moldings, Sheet)

Sherardized Coatings

(see Diffusion Coatings)

Silicides

(see Refractories)

Silicon

American Nickel Alloy Mfg. Corp., NY (w,aa)
Belmont Smelting & Refining Works, Inc., NY (aa)
du Pont de Nemours, E. I. & Co., Inc., Del (w)
Eagle-Picher Co., Ohio (aa)
Foote Mineral Co., Pa (q)
Hardy, Charles, Inc., NY (aa)
Lavin, R. & Sons, Inc., Ill (w)
National Electric Products Corp., Pa (ff)
National-Standard Co., Mich (ff)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (w,bb,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)
Utica General Jobbing Foundry, Inc., NY (aa)
Vanadium Corp. of America (w)

Silicon Bronze

(see Copper)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Silicone Plastics

Adhesive Products Corp., NY (x)
Alpha Wire Corp., NY (ee)
Bakelite Co., Div. of Union Carbide Corp., NY (p,y)
Belko Corp., Md (y)
Bisonite Co., Inc., NY (y)
Colonial Kolonite Co., Ill (bb,cc,ee)
Comco Plastics, Inc., NY (bb,cc,dd, ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn
(y)
Cordo Molding Products, Inc., NY
(y)
Curbell, Inc., NY (bb,cc,dd,ee)
Dodge Fibers Corp., NY (s)
Dow Corning Corp., Mich (p,u,x,y)
Dyna-Therm Chemical Corp., Calif
(p)
Electrofilm, Inc., Calif (t)
Emerson & Cuming, Inc., Mass (u)
Flexible Tubing Corp., Conn (ee)
Formica Corp., Sub. of American Cyanamid Co., Ohio (cc,ee)
General Electric Co., Laminated Products Dept., Ohio
(cc)
General Electric Co., Silicone Products Dept., NY (p,u,x,y)
General Gasket, Inc., Conn (cc)
Glass Reinforced Plastics Corp., Ohio (bb,ee)
Hall, C.P. Co., Ohio (p)
Hewitt-Robins, Inc., Conn (u,cc,ee)
Kurz Kasch, Inc., Ohio (y)
Maloney, F.H. Co., Tex (y)
Mesa Plastics Co., Calif (p,y,bb,cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc)
Minneapolis Honeywell Regulator Co., Minn (u,x)
Narmco Resins & Coatings Co., Calif (x)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
National Vulcanized Fibre Co., Del
(bb,cc,dd,ee)
Panelyte Div., St. Regis Paper Co., NY (x,bb,cc,dd,ee)
Parker, Stearns & Co., Inc., NY (bb, cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Prince Rubber Co., Inc., NY (cc,ee)
Raybestos-Manhattan, Inc., NJ (bb, cc,dd)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn
(x)
Rogers Corp., Conn (u,y,bb,cc,dd)
Roth Rubber Co., Ill
(cc)
Staver Co., Inc., NY (cc,dd)
Stockwell Rubber Co., Inc., Pa (y, bb,cc,dd)
Swedlow Inc., Calif (cc)
Synthane Corp., Pa (bb,cc,dd,ee)
Taylor Fibre Co., Pa
(bb,cc,dd,ee)
Toyad Corp., Pa (u)
Union Carbide Corp., Silicones Div., NY (p,t,u,x,y)
U.S. Polymeric Chemicals, Inc., Conn (s)
Varflex Corp., NY (ee)
Western Felt Works, Ill
(cc)

Silicone Rubber

Adhesive Products Corp., NY (x)
Alpha Wire Corp., NY (ee)
Armstrong Cork Co., Pa (bb,cc,dd)
Belko Corp., Md (y)
Capac Mfg. Corp., Mich (y)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Ill (p)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Colonial Rubber Co., Div. of U. S. Stoneware Co., Ohio (y)
Connecticut Hard Rubber Co., Conn (u,y,bb,cc,dd)
Continental Rubber Works, Pa (bb, cc,dd,ee)
Continental-Diamond Fibre Corp., Del (cc,dd)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Dodge Fibers Corp., NY (s)
Dow Corning Corp., Mich (p,u,x,y)
Dyna-Therm Chemical Corp., Calif
(p)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,bb,cc,dd, ee)
General Electric Co., Chemical & Metallurgical Div., Ill (cc,dd,ee)
General Electric Co., Plastics Dept., Ill (p,y,bb,cc,dd,ee)
General Electric Co., Silicone Products Dept., NY (p,u,y)
Goshen Rubber Co., Inc., Ind
(y)
Hewitt-Robins, Inc., Conn (cc,ee)
Insulation Mfrs. Corp., Ill (cc)
Maloney, F.H. Co., Tex (y)
Mechanical Rubber Products Co., NY (t,u,bb,cc,dd)
Micarta Div., Westinghouse Electric Corp., SC (cc)
Mid-States Rubber Products, Inc., Ind (y)
Minneapolis Honeywell Regulator Co., Minn (u,x)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Paeco Rubber Co., Inc., Ohio (y, dd, ee)
Parker-Hannifin Corp., Parker Seal Div., Ohio (u)
Pawling Rubber Corp., NY (bb,dd,ee)
Permacel, Inc., NJ (t,u,bb,cc)
Prince Rubber Co., Inc., NY (cc, ee)
Raybestos-Manhattan, Inc., NJ (bb, cc,dd)
Raybestos - Manhattan, Inc., Plastic Products Div., Conn
(x)
Rogers Corp., Conn (u,y,cc,dd)
Roth Rubber Co., Ill
(cc)—Ad p 261
Stockwell Rubber Co., Inc., Pa (u,y, bb,cc,dd)
Swedlow, Inc., Calif (cc)
Toyad Corp., Pa (u)
Trostel, Albert Packing, Ltd., Wis (y)
Union Carbide Corp., Silicones Div., NY (p,y,cc,dd)
U.S. Polymeric Chemicals, Inc., Conn (s)
U.S. Stoneware Co., Ohio (y)
Varflex Corp., NY (ee)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Works, Ill
(y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill
(y,bb,cc,dd,ee)

Silver and Its Alloys

Alloy Metal Powders, Inc., Iowa (aa)
Alpha Metals Inc., NJ (n,o,q,bb,cc,dd)
American Metal Climax, Inc., NY (w,aa)
American Platinum & Silver Div., Engelhard Industries, Inc., NY
(n,o,q,v,w,z,aa,bb,cc,dd,ff)
American Products Corp., Ill (dd,ff)
American Silver Co., NY (v,dd,ee,ff)
American Smelting & Refining Co., NY (n,o,q,bb,ee)
Anaconda Co., NY (o)
Baker & Co., Inc., NJ (n,o,v,w,z,aa, bb,cc,dd)
Belmont Smelting & Refining Works, Inc., NY
(o,dd,ff)
Bunker Hill Co., Sales & Fabrication Div., Calif (o)
Cerro de Pasco Sales Corp., NY
(o,w)
Dahlin, C.A. Co., Ill (cc)
Designers Metal Corp., Ill (cc)
Division Lead Co., Ill (ff)
Eastern Smelting & Refining Corp., Mass (n,o,v,w,aa,bb,cc,dd,ee,ff)
Eynon-Dakin Co., Mich (ee)
Federated Metals Div., American Smelting & Refining Co., NY (n)
Fox Products Co., Pa (n)
Fulton Gold Refiners Corp., NY (n,o, q,v,w,aa,bb,cc,dd)
General Plate Div., Metals & Controls Corp., Mass (n,v,w,z,aa,bb,cc,dd)
Gibson Electric Co., Pa
(aa,bb,dd,ff)—Ad p 415
Goldsmith, S. & R. Bros., Co., Ill (n,o,v,w,z,aa,bb,cc,dd)
Handy & Harman, NY
(n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hanovia Chemical & Mfg. Co., NJ (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Hommel, O. Co., Pa
Hudsar, Inc., NJ (w)
Leach & Garner Co., Industrial Div., Mass (n,o,q,v,z,bb,cc,dd)
Lucas-Milhaupt Engineering Co., Wis (dd,ff)
Makepeace, D.E. Div., Engelhard Industries Inc., Mass (n,o,v,z,aa,bb,dd, ee,ff)
Metal Goods Corp., Tex (dd)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ
(aa)—Ad p 415
Minimax Co., Ill (aa)
Nesor Alloy Products Co., NJ (dd,ff)
Ney, J.M. Co., Industrial Div., Conn (v,z,bb,cc,dd,ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Peerless Roll Leaf Co., Inc., NJ (v,dd)
Reade Mfg. Co., Inc., NJ (aa)
Republic Metals Co., Inc., NY (o,w)
Rigidized Metals Corp., NY
(cc, dd)
Rotometals, Calif (dd,ff)
Sel-Rex Corp., NJ
(n,aa)
Ullmann, Inc., Wis (o,ee)
United Wire & Supply Corp., RI (ff)
Vanadium-Alloys Steel Co., Pa (aa)
Western Gold & Platinum Co., Sub. of Wilbur B. Driver Co., Calif (aa, cc,dd,ff)
Wildberg Bros. Smelting & Refining Co., Calif (n,o,v,w,z,aa,bb,cc,dd,ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Wilson, H.A. Div., Engelhard Industries, Inc., NJ
(cc)

Slush Moldings

(see Moldings)

Solders

A & A Die Casting Co., Calif
Abalon Precision Mfg. Corp., NY
All-State Welding Alloys Co., Inc., NY
American Emblem Co., Inc., NY
American Metal Climax, Inc., NY
American Products Corp., Ill
American Smelting & Refining Co., NY
Anchor Metal Co., Inc., NY
Belmont Smelting & Refining Works, Inc., NY
Bishop, J. & Co. Platinum Works, Pa
Chemical Development Corp., Mass
Consolidated Fruit Jar Co., NJ
Division Lead Co., Ill
Empire Metal Co., NY
Eutectic Welding Alloys Corp., NY
Falstrom Co., NJ
General Findings & Supply Co., Industrial Div., Mass
Hayden Wire Works, Inc., Mass
Ideal Can Co., Mass
Indium Corp. of America, NY
Kenmore Machine Products, Inc., NY
Kester Solder Co., Ill
Kling Metal Spinning & Stamping Co., NY
L. & R. Mfg. Co., NJ
Langsenkamp, F.H. Co., Ind
Lucas-Milhaupt Engineering Co., Wis
Lundquist Tool & Mfg. Co., Inc., Mass
Magnesium Co. of America, Ind
Magnesium Products of Milwaukee, Inc., Wis
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass
Metal Goods Corp., Mo
Metallizing Co. of Los Angeles, Inc., Calif
Midwest Stamping & Mfg. Co., Ohio
National Lead Co., NY
Ney, J.M. Co., Conn
Presswork, Inc., Mich
Ren Plastics, Inc., Mich
Republic Metals Co., Inc., NY
Reynolds Aluminum Supply Co., Ga
Rotometals, Calif
Ruby Chemical Co., Ohio
United Wire & Supply Corp., RI
Waterman Industries, Inc., Calif
Wayne Chemical Products Co., Mich
West Haven Foundry Co., Conn
Whitehead Metal Products Co., Inc., NY
Wildberg Bros. Smelting & Refining Co., Calif
Williams Gold Refining Co., Inc., NY

Spinnings

Ace Metal Spinning, Ill (a,b,c,d,e,f, g,h,j)
Acme Metal Spinning, Inc., Minn (a b,c,d,e,f,g,h,j)
Aluminum Co. of America, Pa (a)
Aluminum Goods Mfg., Wis (a)
Aluminum Specialty Co., Wis (a)
Ampco Metal, Inc., Wis (b)
Anchor Metal Spinning Co., Ohio (a, b,c,d,e,f,g,h,j)
Bartlett-Thompson Co. Inc., Mass (a, b,f,g)
Bergfels, William & Co., NJ (a,b,c, f,g,j)
Biersach & Niedermeyer Co., Wis (a,g)
Broadway Mfg. Co., Wis (a,b,c,f,g)
Brooks & Perkins, Inc., Mich
(a,e,h)
Clover Industries, Inc., NY (a)
Commerical Shearing & Stamping Co., Ohio (a,b,e,f,g)
Craft Mfg. Co., Ill (a,b,c,d,f,g)
Craft Metal Spinning Co., Ill (a,b,f,g)
Cyril Bath Co., Ohio (a,g)
Dahlin, C.A. Co., Ill (a,b,d,e,f,g,h,j)
Dow Chemical Co., Mich (e)
Emerson-Sack-Warner Corp., Mass (a, b,c,e,f,g,h,j)

Garco Mfg. Co., Inc., Ill (a,b,e,f,g,h,j)
General Alloys Co., Mass (a,b,f,g)
Greene, G.G. Corp., Pa (a,g)
H & H Tube & Mfg. Co., Mich (b)
Hardy Mfg. Corp., Ind (a,g)
Kelsey-Hayes Co., Mich (g)
Kenmore Machine Products, Inc., NY (b)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,j)
Klinzing, A.F. Co., Inc., Wis (b)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Magline, Inc., Mich (e)
Magnesium Co. of America, Ind (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Manufacturers Service, Inc., Ohio (a,b,g)
Mirro Aluminum Co., Wis (a)
Morse, Fred W. Co., RI (a,b,c,g,j)
Muncie Metal Spinning, Inc., Ind (a,b,g)
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Murray Tube Works, Inc., NJ (a,b,g)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g)
Perrin, Edward C. Co., NJ (a,b,g)
Phoenix Products Co., Wis (a,b,c,d,e,f,g,h,j)
Precision Metal Spinning Co., Mich (a,b,c,e,f,g)
Premier Metal Works, Inc., Ill (a,b,g)
Regal Ware, Inc., Wis (a,b,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (b)
Reynolds Metals Co., Va (a)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Seattle Boiler Works, Inc., Wash (a,g)
Smith-Victor Corp., Ind (a)
Solar Aircraft Co., Calif (g)
Spincraft, Inc., Wis (a,b,d,e,f,g,h,j)
Stainless Metals, Inc., NY (c,f,h)
Stirrup Metal Products Corp., NJ (a,b,g)
Teiner, Roland Co., Inc., Mass (a,b,c,e,f,g,h)
Toledo Stamping & Mfg. Co., Ohio (a,b,g,h)
Torngren, C.W. Co., Inc., Mass (a,b,c,e,f,g,h,j)
Ward, H.H. Co., Pa (a,b)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (a,b,c,e,f,g)

Sprayed Coatings

(see Metallized Coatings)

Stampings, Punchings

(see also Drawn, Pressed Parts)

A & A Die Casting Co., Calif (b)
Abalon Precision Mfg. Corp., NY (a,b,c,g)
Ackermann Mfg. Co., W.Va (g)
Acme Mfg. & Gasket Co., Pa (a,b,f,g)
Acme Metal Spinning, Inc., Minn (a,b,c,e,f,g,j)
Acme Stamping & Mfg. Co., Pa (a,b,g)
Acorn Sheet Metal Mfg. Co., Inc., Ill (a,g)
Acro Metal Stamping Co., Wis (a,b,f,g)
Adams, I.G. Metalware Co., Mo (a,b,c,e,f,g,j)
Advance Stamping Co., Mich (a,b,c,d,f,g,j)
Aerolite Electronics Corp., NJ (a,b,c,g)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (g)
All-Form Metal Products Co., Ohio (a,b,c,d,e,f,g,j)
Allied Products Corp., Mich (a,g)
Alloy Products Corp., Wis (a,f,g,h)—Ad p 408
Almco Steel Products Corp., Ind (a,b,g)
Alofs Mfg. Co., Mich (a,b,g)
Alox Mfg. Co., Mo (a,b,c,f,g)
Alpha Metals, Inc., NJ (a,g)
Aluminum Co. of America, Pa (a)
Aluminum Goods Mfg., Wis (a)
Aluminum Specialty Co., Wis (a,g)
American Brass Co., Sub. of Anaconda Co., NY (b)—Ad p 377
American Emblem Co., Inc., NY (a,b,g)
American Kitchens Div., Avco Mfg. Corp., Ind (g)
American Mfg. Co., Tenn (a,g)
American Sheet Metal Works, Inc., Conn (a,b,g)
American Silver Co., NY (a,b,e,f,g)
American Stamping Co., Ohio (a,b,g)
Anchor Metal Spinning Co., Ohio (a,b,c,d,e,f,g,h,j)
Anderson, O.L. Co., Inc., Mich (a,b,c,e,f,g,h,j)
Anderson-Bolling Mfg. Co. Mich (a,g)
Anthes Force Oiler Co., Iowa (a,g)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Armor Metal Products Co., Ohio (a,g)
Art Wire & Stamping Co., NJ (a,b,c,d,f,g)—Ad p 392
Arvin Industries, Inc., Ind (a,g)
Ashtabula Mfg. Co., Ohio (g)
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Atkins Saw Div., Borg-Warner Corp., Ind (g)
Atlas Metal Parts Co., Wis (a,b,c,g)
Auburn Mfg. Co., Conn (a,b,c,d,e,f,g)—Ad p 420
Auel Industries, Pa (a,b,f,g)
Auld, D.L. Co., Ohio (a,b,c)
Autel Electronics Co., Precision Machine & Welding Div., NJ (a,b,c,e,g,h)
Automotive Rubber Co., Inc., Mich (f,g)
Backus Novelty Co., Pa (a,b,c,f,g)
Barclay Mfg. Co., Ind (c)
Barium Steel Corp., NY (g)
Bartlett-Thompson Co., Inc., Mass (a,b,f,g)
Bay State Stamping Co., Mass (a,b,g)
Beacon Metal Mfg. Co., NY (a,b,c,d,e,f,g,h,j)
Behringer Metal Works, Inc., NJ (a,b,c,g)
Belmet Products, Inc., NY (a,b,g)
Benjamin Electric Mfg. Co., Ill (a,b,g)
Bennett Mfg. Co., NY (a,b,e,g)
Bethlehem Steel Co., Pa (g)
Biersach & Niedermeyer Co., Wis (a,b,c,g)
Bingham Herbrand Corp., Bingham Stamping Div., Ohio (g)
Blacher Bros., Inc., RI (a,b,g)
Blaco Mfg. Co., Ohio (b,g)
Blickman, S., Inc., NJ (a,b,c,g)
Boots Aircraft Nut Corp., Conn (g)
Borg-Warner Corp., Ingersoll Products Div., Ill (g)
Brandt, Charles T., Inc., Md (a,b,e,f,g)
Brewer-Titchener Corp., NY (a,g)
Brooks & Perkins, Inc., Mich (a,e,h)
Burgess-Norton Mfg. Co., Ill (c)
Carbo Tool & Die Co., Ohio (c)
Carroll Pressed Metal, Inc., Mass (a,b,f,g)
Cartwright, R. Tube Products Co., Mich (a,b,g)
Cincinnati Pump & Mfg. Co., Inc., Ohio (g)
Clendenin Bros., Inc., Md (a,b)
Cleveland Metal Products Co., Ohio (a,b,c,f,g)
Cleveland Pressed Products Corp., Ohio (a,b,g)
Clover Industries, Inc., NY (a)
Cly-Del Mfg. Co., Inc., Conn (a,b,f,g,j)
Columbia Metal Stamping Co., Ohio (a,g)
Columbian Steel Tank Co., Mo (g)
Columbus Dental Mfg. Co., Ohio (a,b,c,g)
Columbus Jack Corp., Ohio (a,c,g)
Comerford Mfg. Co., Inc., Conn (a,b,c,e,f,g,j)
Commercial Shearing & Stamping Co., Ohio (a,b,f,g)
Consolidated Fruit Jar Co., NJ (a,b,c,d,g,j)
Cooley, W.J. & Co., Tenn (a,b,g)
Craft Mfg. Co., Ill (a,b,c,d,f,g)
Croname Inc., Ill (a,b,f,g,j)
Crosby Co., NY (a,b,g)
Crown Metal Co., Wis (d)
Cuyahoga Stamping Co., Ohio (a,b,g)
Cyril Bath Co., Ohio (a,e,f,g,h)
Dahlin, C.A. Co., Ill (a,b,d,e,f,g,j)
Dana Corp., Auburn Div., Ind (g)
Danby Mfg. Co., Mich (a,b,g)
Dare Products, Inc., Mich (g)
Day Co., Minn (a,g)
Dayton Rogers Mfg. Co., Minn (a,b,g)
Dearborn Stamping Co., Mich (g)
Defiance Metal Products Co., Ohio (a,g)
Defiance Stamping Co., Ohio (g)
Detroit Stamping Co., Mich (a,b,g)—Ad p 382
Dirilyte Co. of America, Inc., Ind (a,b)
Division Lead Co., Ill (d)
Dixon Corp., RI (k)
Doehler-Jarvis Div., National Lead Co. Ohio (a)
Dolin Metal Products, Inc., NY (g)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Dudek & Bock Spring Mfg. Co., Ill (a,g)
Duplex Mfg. Corp., NY (a,g)
Duplican Co., Inc., Mass (a,b,c,e,f,g,h,j)
Earley, Sam C. Corp., Ohio (a,b,g)
Eastern Tool & Mfg. Co., NJ (a,b,c,g)
Eastern Tool & Stamping Co., Inc., Mass (a,b,c)
Electric Auto-Lite Co., Ohio (a,b,g)
Electric Materials Co., Pa (b)
Electronic Parts Mfg. Co., NJ (c,f,g)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a,b,c,f,g)
Empire Spring Co., Ohio (a,b,g)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Enamel Products Co., Ohio (a,c)
Etched Products Corp., NY (a,b,g)
Evans, George Corp., Ill (a)
Eureka Electric Products Co., Pa (a,b)
Everard Tap & Die Corp., NY (a,b,f,g)
Fabristeel Products, Inc., Mich (g)
Falstrom Co., NJ (a,b,e,g)
Farwell Metal Fabricating, Minn (a,b,e,f,g)
Federal Tool Corp., Ill (a,b,c,g)
Federal Tool & Mfg. Co., Minn (a,b,c,f,g)
Figley Die & Stamping Co., Ohio (a,b,g)
FitzSimons Mfg. Co., Mich (a,b,g)
Fletcher Enamel Co., W.Va (a,b,c,d,e,f,g)
Follansbee Steel Corp., Sheet Metal Specialty Div., W.Va (a,b,g)
Forg, Peter Mfg. Co., Mass (a,b,c,g)
Fox Co., Ohio (a,b,c,g)
Fox Products Co., Pa (c)
Fryling Mfg. Co., Pa (a,b,f,g,j)
Garco Mfg. Co., Inc., Ill (a,b,c,e,f,g,h,j)
Gary Steel Products Corp., Va (a,g)
General Alloys Co., Mass (a,b,f,g)
General Extrusions, Inc., Ohio (a)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
General Gasket, Inc., Conn (a,b,c,d,g)
Geometric Stamping Co., Ohio (a,b,g)
Gerstenslage Co., Ohio (a,g)
Geuder, Paeschke & Frey Co., Wis (a,c,f,g)
Giant Grip Mfg. Co., Wis (a,c,e,f,g,h)
Gibson Electric Co., Pa (b)
Grammes, L.F. & Sons, Inc., Pa (a,b,g)
Grand Haven Stamped Products Co., Mich (a,b,g,j)
Grand Sheet Metal Products Co., Consumer Products Div., Ill (a,b,c,e,f,g,h,j)
Greene, G.G. Corp., Pa (a,b,e,f,g,j)
Greene Mfg. Co., Wis (a,g)
Grigoleit Co., Ill (a,g)
Guarantee Specialty Mfg. Co., Ohio (a,b,c,g,j)
H.K. Metal Craft Mfg. Corp., NY (a,b,c,g,j)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

H P L Mfg. Co., Ohio (a,b,g)
Haigh Mfg. Co., Mich (a,b,f)
Hardy Mfg. Corp., Ind (a,b,g)
Headly Mfg. Co., Ill (a,b,c,e,f,g,h,j)
Heyplan Mfg. Co., NJ (a,b,f,g)
Hoofer Mfg. Co., Ill (a,g)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Hunter Spring Co., Pa (b,g)
Ideal Can Co., Mass (a,b,c,g)
Indium Corp. of America, NY
(d)
Indus Corp., Ind (g)
Industrial Precision Products, Ill (a,b,c,e,f,g,h,j)
Ingram-Richardson, Inc., Ind (g)
Inshield Die & Stamping Co., Ohio (a,b,g)
Instrument Specialties Co., Inc., NJ
(b)—Ad p 381
Interlake Mfg. Co., Mich (a,g)
Irvington Form & Tank Corp., NY (a,b,g)
Irwin-Sensenich Corp., Pa (g)
Jackson Auto Radiator, Ill (a,b,g)
Jarco Metal Products, NY (a,b g,j)
Judd Industries, Inc., Ohio (a,b,g)
K-D Mfg. Co., Tex (g)
Kaiser Steel Corp., Calif (g)
Kees, F.D. Mfg. Co., Neb (a,b,g)
Kelley Mfg. Co., Tex (a,b,g)
Kenmore Machine Products, Inc., NY (b)
Kickhaefer Mfg. Co., Wis (a,b,g)
King Laboratories, Inc., NY (a,b,c,f,g)
Kirchhof Patent Co., Inc., NY (a,b,c,f,g,j)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,j)
Koehler Mfg. Co., Mass (a,b,c,d,g)
Krueger & Hudepohl, Inc., Ohio (a,b,c,f,g)
Laminated Shim Co., Conn (a,b,g)
Lansing Stamping Co., Mich (g)
Larkin Specialty Mfg. Co., Calif (a,b,g)
Larson Tool & Stamping Co., Mass (a,b,c,e,f,g,h,j)
Laystrom Mfg. Co., Ill (a,b,c,f,g,j)
Leake Engineering Co., Mich (a,b,c,d,e,f,g,h,j)
Linden & Co., Inc., RI (a,b,g)
Littleford Bros. Inc., Ohio (a,b,c,f,g)
Lukens Steel Co., Pa
(a,b,e,f,g,h)
Lundquist Tool & Mfg. Co., Inc., Mass (a,b,c,e,f,g,h)
Lynn, Gary Co., Ohio (a,b,g)
Machine Products Corp., Ohio (a,b,d,f,g)
Magline, Inc., Mich (e)
Magnesium Co. of America, Ill (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Magnetic Stamping Co., Pa (a,b,g)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (b)
Maloney, F.H. Co., Tex (g)
Manganese Steel Forge Co., Pa (g)
Manufacturers Service, Inc., Ohio (a,b,g)
Mayville Metal Products Co., Wis (a,b,g)
McDowell Mfg. Co., Pa (a,b,g)
McKinney Mfg. Co., Pa (a,b,e,f,g)
McLanahan & Stone Corp., Pa (c,g)
Melco Wire Products, Calif (a)
Melray Mfg. Co., Ill (a,b,c,d,e,f,g,h,j)
Metal Parts & Stamping Co., Ohio (a,b,c,f,g,h,j)
Metallurgical Products Co., Pa (a,b,f,h,j)
Micacraft Products, Inc., NJ (a)
Midwest Stamping & Mfg. Co., Ohio (a,b,f,g)
Milwaukee Stamping Co., Wis (a,b,g)
Mirro Aluminum Co., Wis (a)
Misner Corp., Neb (a,b,c,g)
Monarch Tool & Mfg. Co., Ky (a,b,c,g)
Morrison Steel Products, Inc., NY (g)
Morse, Fred W. Co., RI (a,b,c,g,j)
Mueller Machine Products, Inc., Wis (a,b,c,d,f,g)
National Gasket & Washer Mfg. Co., Inc., NY (a,b,c,d,e,f,g,h,j)
National Lead Co., NY (a,c,h)
National Metal Products Co., Pa (a,c,g)
National Supply Co., Pa (g)
Nichols, L.O. & Son Mfg. Co., Mo (a,b,c,g)
Nigg Engineering Corp., Calif (a,b,c,g)
Noera Mfg. Co., Conn (a,b,g)
Norcross, C.S. & Sons Co., Ill (g)
Nylok Corp., NJ (a,b,c,e,g)
Ohio Nut & Washer Co., Ohio (a,g)
Olean Electro Plating Co., NY (a,b,g)
Ormond Mfg., Co., Inc., NJ (a,b,f,j)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g)
Paragon Spring Co., Ill (a,b,c,f,g)
Parish Pressed Steel Div., Dana Corp., Pa (a,g)
Parker, Charles Co., Conn (a,f)
Parker Metal Goods Co., Mass (a,b,g)
Peck Spring Co., Conn (a,b,c,f,g,h)
Peerless Products Industries, Ill (a,b,g)
Pemco Wheel Co., Mich (g)
Penn Fibre & Specialty Co., Inc., Pa (a,b,c,d,e,f,g,j)
Penrod, Floyd & Sons Tool & Engineering Corp., Ind (a,b,g)
Perrin, Edward C. Co., NJ (a,b,g)
Peterson Products Corp., Ill (a,b,f,g)
Philadelphia Enameling Works Inc., Pa (a,b,g)
Phoenix Iron & Steel Co., Pa (a,g)
Pierce Governor of Ohio, Inc., Ohio (a,g)
Pioneer Stamped Products Co., NY (a,b,c,d,e,f,g,h)
Pittsburgh Forgings Co., Mich (g)
Plume & Atwood Mfg. Co., Conn (a,b,f,g)
Porter, H.K., Inc., Forge & Fittings Div., Ohio (a,g)
Powell Pressed Steel Co., Ohio (a,g)
Premier Metal Works, Inc., Ill (a,b,f,g)
Pressed Steel Co., Pa (a,b,d,f,g,j)
Presswork, Inc., Mich (a,b,d,f,g,j)
Prestole Corp., Ohio (a,g)
Queen Products Co., Inc., Ky (a,b,g)
Reed & Prince Mfg. Co., Mass (a,b,c,g)
Regal Ware, Inc., Wis (a,b,g)
Reliable Spring & Wire Forms Co., Ohio (a,b,f,g)
Republic Steel Corp., Ohio
(g)
Revere Copper & Brass, Inc., NY (a,b,c,f,g,j)
Reynolds Metals Co., Va (a)
Rochester Novelty Works, Inc., NY (a,g)
Rockwell-Standard Corp., Bossert Stamping Div., NY
(a,b,c,d,e,f,g,h,j)—Ad p 412
Rolock, Inc., Conn (f)
Roth Steel Products Co., Ohio (g)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
St. Marys Carbon Co., Pa (b)
Sargent & Greenleaf, Inc., NY (a,b,g)
Scovill Mfg. Co., Mill Products Div., Conn
(a,b,c,f,g)
Security Cos., Mich (a)
Security Sash & Screen Co., Mich (a)
Servwell Products Co., Ohio (b,g)
Shakeproof Div., Illinois Tool Works, Ill (b,g)
Shank Metal Products Co., NY (a,g)
Shelby Mfg. Co., Ohio (g)
Sheller Mfg. Corp., Mich (g)
Sierra Electric Corp., Calif (b,g)
Sillcocks Miller Co., NJ (a,b,f,g)
Simonsen Metal Products Co., Ill (a,g)
Sinclair Co., Mass (b,g)
Sioux City Foundry & Boiler Co., Iowa (g)
Smithers Tool & Machine Products, Inc., NY (g)
Smith-Victor Corp., Ind (a,g)
Smoot-Holman Co., Calif (g)
Sommer Metalcraft Corp., Ind (a,g)
South River Metal Products Co., Inc., NJ (a,e,g)
Southern Car & Mfg. Co., Inc., Ala (a,b,g)
Southwestern Porcelain Steel Corp., Okla (g)
Spincraft, Inc., Wis (a,b,g)
Stainless Metals, Inc., NY (c,f,h)
Stamford Metal Specialty Co., Inc., NY (a,f,g)
Standard Forge & Axle Co., Inc., Ala (g)
Standard Nut & Bolt Co., RI (a,b,f,g)
Standard Steel Sections, Inc., NY (a,b,c,g)
Stanley Industrial Sales, Stanley Works, Conn (g)
Star Heel Plate Co., Inc., NJ (g)
Star Stamping Co., Mich (a,b,g)
Staver Co., Inc., NY (a,b,c,d,e,f,g,h,j)
Steel Heddle Mfg. Co., Pa (a,b,c,e,f,g,h,j)
Steel Industries, Inc., Ind (a,b,g)
Steinen, Wm. Mfg. Co., NJ (a,b,c,g)
Stenman, Bror F., Mass (a,g)
Stimpson, Edwin B. Co., Inc., NY (a,b,f,g,j)
Stirrup Metal Products Corp., NJ (a,b,c,g)
Superior Mfg. Co., Pa (g, j)
Superior Spinning & Stamping Co., Ohio (a,b,f,g)
Sylvania Electric Products Inc., Parts Div., Pa
(a,b,c,f,g)
Textile Shield Co., Inc., Mass (a,b,g)
Thompson Products, Inc., Ohio (g)
Thompson-Bremer & Co., Ill (a,b,c,f,g,h)
Toledo Stamping & Mfg. Co., Ohio (a,b,g,h)
Transue & Williams Steel Forging Corp., Ohio (f,g)
Triangle Stamping Co., Ohio (a,b,c,d,f,g,j)
Turner & Seymour Mfg. Co., Conn (a,b,g)
United Metal Products Corp., Mich (a,b,c,g)
United Screw & Bolt Corp., Ill (a,b,g)
United Shoe Machinery Corp., Mass (a,b,f,g,j)
U.S. Gasket & Shim Co., Ohio (a,b,c,d,e,f,g,h,j)
United-Carr Fastener Corp., Mass (a,b,g)
Unity Machine & Tool Corp., Pa (a,b,g)
Van Valkenburg, L.A. Co., Mass (a,b,c,f,g)
Variety Stamping Corp., Ohio (a,b,c,g)
Volkert Stampings, Inc., NY (b,f,g)
WLS Stamping Co., Ohio (a,b,c,d,e,f,g,h,j)
Wabash Metal Products Co., Inc., Ind (a,b,g)
Wagner, E.P. Mfg. Co., Wis (a,b,c,g,j)
Wagner Specialty Co., Wis (a,b,c,g,j)
Wall, P. Mfg. Co., Pa (a,b,g)
Wall Tube & Metal Products Co., Tenn (g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Waterbury Buckle Co., Conn (a,g,j)
Waterbury Cos., Inc., Conn (a,b,g)
Waterbury Pressed Metal Co., Conn (a,b,f,g)
Waterman Industrial, Inc., Calif (a,b,g)
Wayne Foundry & Stamping Co., Mich (a,b,e,g,h)
Weatherhead Co., Ind (a,b,g,h)
Weber-Knapp Co., NY (a,g)
Welding Apparatus Co., Ill (a,f,g)
Wesbar Stamping Corp., Wis (a,g)
Wesco Spring Co., Ill (g)
Western Tool & Die Works, Ore (a,b,g)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
(f)
Wilder Mfg. Co., Inc., Calif (a,c,g)
Williams, F.B. Co., Ill (g)
Williams, H.E. Products Co., Mo (a,b,c,g,j)
Wirth, Carl & Son, Inc., NY (a,b,c,g)
Wisconsin Gasket & Mfg. Co., Wis (a,b,g)
Wisconsin Tool & Stamping Co., Ill (a,b,d,f,g,j)
Wood, John Co., Minn (g)
Woolf Aircraft Products, Inc., Mich (a,b,g)
Worcester Pressed Steel Co., Mass (a,b,c,e,f,g,h,j)
Worcester Stamped Metal Co., Mass (a,b,e,f,g,h,j)
Worth Co., Wis (a,b,c,g)
Wrought Washer Mfg. Co., Wis (a,b,d,e,f,g,h,j)
Wuest Bros., Inc., Ky (a,b,c,f,g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Mfg., Inc., Ohio (a,g)
Youngstown Sheet and Tube Co., Ohio (g)

Steatite

(see Ceramics)

Steel, Carbon

Acme Tube, Inc., NJ (ee)
Acme-Newport Steel Co., Ky (w,z,cc)
Advance Screw Products Co., Inc., Wis (o)
Advance Stamping Co., Mich (dd)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (ee)
Alan Wood Steel Co., Pa (o,q,w,z,cc,dd)
Albert Wright Screw Machine Products, Calif (bb)
Alco Products, Inc., NY (q,aa)
Allegheny Ludlum Steel Corp., Pa
(dd)
Alloy Metal Powders, Inc., Iowa (aa)
Almco Steel Products Corp., Ind (o,z,bb,cc,dd)
Amalgamated Steel Corp., Ohio (o,bb)
American Cast Iron Pipe Co., Ala
(ee)
American Metal Products, Inc., Ohio (z,cc)
American Silver Co., NY (v,dd)
American Steel and Wire Div., U. S. Steel Corp., Ohio
(o)—Ad pp 78-79
Ames, W. & Co., NJ (o)
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (bb,ff)
Aristoloy Steel Div., Copperweld Steel Co., Ohio (o,q,w)
Armco Steel Corp., Ohio (o,z,bb,cc,dd,ff)
Armco Steel Corp., Sheffield Div., Mo (o,q,w,z,bb,cc,dd,ff)
Athenia Steel Div., National Standard Co., NJ (dd)
Atlantic Steel Co., Ga (o,q,w,z,bb,cc,dd,ee,ff)
Austenal Co., Div. of Howe Sound Co., NY (w)

Babcock & Wilcox Co., Tubular Products Div., Pa
(ee)—Ad p 383
Barium Steel Corp., NY (q,w,z,ee)
Baxter Foundry & Machine Works, Inc., Id (o,z,bb,cc,dd)
Bethlehem Steel Co., Pa (o,q,z,cc,dd,ee,ff)
Biddle Screw Products Co., Ind (bb,ee)
Bliss & Laughlin, Inc., Ill (o)
Brainard Steel Div., Sharon Steel Corp., Ohio (ee)
Burkhardt Steel Co., Colo (o,z,cc,dd,ee)
Byers, A.M. Co., Pa (o,q,w,z,cc,dd)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Webb Wire Div., NJ (ff)
Caspers Tin Plate Co., Ill (cc,dd)
Castle, A.M. & Co., Ill (o,z,bb,cc,dd,ee,ff)
Central Fabricators, Inc., Ohio (z,bb,cc,ee)
Chicago Steel Service Co., Ill (o,z,bb,cc,dd)
Cincinnati Pump & Mfg. Co., Inc., Ohio (ff)
Clad-Rex Corp., Ill
(cc)
Clark Perforating Co., Mich (cc,dd)
Clayton Mark & Co., Ill (ee)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Columbia-Geneva Steel Div., U. S. Steel Corp., Cailf (o,q,z,cc,dd,ee)
Connors Steel Div., H.K. Porter Co., Inc., Ala (o,q,w,dd)
Continental Steel Corp., Ind (o,q,bb,ff)
Crucible Steel Co. of America, Pa
(o,q,w,z,bb,cc,dd,ee,ff)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,z,bb,cc,dd,ff)
Cumberland Steel Co., Md (o)
Dahlin, C.A. Co., Ill (z,cc,dd,ee)
Designers Metal Corp., Ill (cc)
Detroit Steel Corp., Portsmouth Div., Mich (q,w,bb,cc)
Dixon Sintaloy, Inc., Conn (o)
Dudek & Bock Spring Mfg. Co., Ill (dd,ff)
Eaton Mfg. Co., Reliance Div., Ohio (o,ff)
Edgcomb Steel & Aluminum Corp., NJ (o,z,cc,dd)
Elliott Bros. Steel Co., Pa (cc,dd)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (z,cc)
Enterprise Wheel & Car Corp., Va (o,z,cc)
Finkl, A. & Sons Co., Ill (w)
Follansbee Steel Corp., W.Va (cc,dd)
Forg, Peter Mfg. Co., Mass (cc)
Fort Howard Steel & Wire Co., Wis (o)
Franklin Steel Div., Borg-Warner Corp., Pa (o)
Frasse, Peter A. & Co., Inc., NY
(o,bb,cc,dd,ee,ff)
Fromson Orban Co., Inc., NY (ee)
Gary Steel Products Corp., Va (o,z,cc)
General Motors Corp., Rochester Products Div., NY
(ee)
Granite City Steel Co., Ill (w,z,cc)
Great Lakes Steel Corp., Div. of National Steel Corp., Mich (z,cc,dd)
Green River Steel Corp., Ky (o,q,w)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (o,bb,ee,ff)
Houston Blow Pipe & Sheet Metal Works, Tex (o,z,cc)
Inland Steel Co., Ill (o,z,cc,dd)
Inshield Die & Stamping Co., Ohio (cc)
Isaacson Iron Works, Wash (q,w)
Jackson Steel Products, Inc., NY (ee)
Jones & Laughlin Steel Corp., Pa (o,q,z,bb,cc,dd,ee,ff)
K-D Mfg. Co., Tex (o)
Kaiser Steel Corp., Calif (o,q,w,z,bb,cc,dd,ee)
Keystone Drawn Steel Co., Pa (o)
Keystone Steel & Wire Co., Ill (w,bb)
Kinkead Industries, Inc., Ill (o,z,bb,cc,dd)
Korhumel Steel and Aluminum Co., Ill (o,z,bb,cc,dd,ff)
Laclede Steel Co., Mo (o,q,w,bb,dd,ee,ff)
Larson, Charles E. & Sons, Inc., Ill (o)
La Salle Steel Co., Ill (o)
Levinson Steel Co., Pa (o,z,bb,cc,dd)
Lock Joint Tube Co., Inc., Ind (ee)
Lockport Mfg. Co., Ill (z)
Lukens Steel Co., Pa
(w,z)
Lundquist Tool & Mfg. Co., Inc., Mass (bb,cc,dd,ee,ff)
Luria Engineering Co., Pa (z,bb,cc)
Mahon, R.C. Co., Mich (o,z,cc,dd)
Makepeace, D.E. Div., Engelhard Industries Inc., Mass (o,dd,ee)
Mallory-Sharon Metals Corp., Ohio
(cc)
McCarter Iron Works, Inc., Pa (o,z,bb,cc)
McGregor-Michigan Corp., Mich (z)
McInnes Steel Co., Pa (o)
McLouth Steel Corp., Mich (cc,dd)
Mechanical Steel Tubing Corp., NY (ee)
Metal Forming Corp., Div. of Vanadium-Alloys Steel Co., Ind (ee)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Michigan Seamless Tube Co., Mich (ee)
Midvale-Heppenstall Co., Pa (w)
Modern Plating Corp., Ill (z)
Morrisville Foundry Co., Inc., Vt (bb,cc,dd)
Murray, A.B. Co., Inc., NJ (ee)
Narragansett Boiler Works, Inc., RI (o,z,bb,cc,ee)
National Galvanizing Co., Pa (z,bb,cc,ee)
National Lock Washer Co., NJ (ff)
National Supply Co., Industrial Products Div., Calif (o,q,w)
National Tube Div., U.S. Steel Corp., Pa (ee)
National U.S. Radiator Corp., Plastic Metals Div., Pa (aa)
National-Standard Co., Mich.
(dd,ff)—Ad p 375
Nesor Alloy Products Co., NJ (ff)
New York Iron Roofing & Corrugating Co., Inc., NJ (cc)
Newman-Crosby Steel Co., RI (dd)
Nikoh Tube Co., Ill (bb,cc,dd,ee)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Northwestern Steel & Wire Co., Ill (o,q,w,z,bb,ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Ormond Mfg. Co., Inc., NJ (cc,dd,ff)
Pacific States Steel Corp., Calif (o,q,w)
Pacific Tube Co., Calif (o)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Peninsular Steel Co., Mich (o,z)
Phoenix Iron & Steel Co., Pa (z)
Phoenix Mfg. Co., Ill (o)
Pittsburgh Forgings Co., Mich (o,q)
Pittsburgh Steel Co., Pa (q,w,bb,cc,dd,ee,ff)
Precision Tube Co., Inc., Pa (ee)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Ohio
(o,q,w,z,bb,cc,dd,ee,ff)
Reynolds Aluminum Supply Co., Ga (cc)
Rigidized Metals Corp., NY
(cc,dd)
Roebling's, John A. Sons Corp., NJ (bb,dd,ff)
Rome Mfg. Div., Revere Copper & Brass Inc., NY (ee)
Rome Strip Steel Co., Inc., NY (o,z,dd,ff)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
St. Louis Steel Casting, Inc., Mo (o)
Sandusky Foundry & Machine Co., Ohio
(ee)
Sandvik Steel, Inc., NJ
(dd)
Saran Lined Pipe Co., Mich (ee)
Sawhill Tubular Products, Inc., Pa (ee)
Scudder, E.J. Foundry & Machine Co., NJ (bb,ee)
Service Steel Div., Van Pelt Corp., Mich (ee)
Sharon Steel Corp., Pa
(q,w,z,cc,dd)
Sharpsville Steel Fabricators, Inc., Pa (o,z,bb,cc)
Shaw-Kendall Engineering Co., Ohio (ee)
Simonds Saw & Steel Co., Mass (o,cc)
Smith-Moon Steel Co., Inc., Kan (o,z,cc)
Solar Steel Corp., Ohio (o,bb,cc,dd,ee)
Sonken-Galamba Corp., Kan (z,bb,cc,ee)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio
(dd)—Ad pp 94-95
Southern Fabricating Co., Inc., Ala (ee)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (q,w)
Star Heel Plate Co., Inc., NJ (o,z,bb,cc,dd,ee,ff)
Sun Steel Co., Ill (o,q,z,bb,cc,dd)
Superior Drawn Steel Co., Pa (o,bb,ff)
Superior Steel Div., Copperweld Steel Co., Pa (dd)
Superior Tube Co., Pa
(ee)
Sylvania Electric Products, Inc., Parts Div., Pa
(ff)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (o,q,z,cc,dd)
Thomas Strip Div., Pittsburgh Steel Co., Pa (dd)
Thompson Industries, inc., NY (bb)
Thompson Wire Co., Mass (dd)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (ee)
Topeka Foundry & Iron Works Co., Inc., Kan (o,z,bb,cc,dd)
Trojan Steel Co., W.Va (o,z,bb,cc,dd)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Uddeholm Co. of America, Inc., NY (bb,dd,ee)
Udylite Corp., Mich (n)
Union Iron Works, Wash (o,z,cc,dd,ee)
Union Steel Corp., NJ (dd)
United Screw & Bolt Corp., Ill (bb,cc,dd,ff)
U.S. Challenge & Challenge Co., Ill (bb)
U.S. Gasket & Shim Co., Ohio (cc,dd)
U. S. Steel Corp., Pa
(o,q,z,cc,dd)—Ad pp 84-85
U.S. Steel Supply Div., U.S. Steel Corp., Ill (o,z,cc,dd,ee)
Vanadium-Alloys Steel Co., Pa (o,q,w,z,aa,bb,cc,ff)
Vulcan Rail & Construction Co., NY (o,dd,ee)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (o,q,w,bb,ff)
Wallace Tube Co., Div. of Wallace Supplies Mfg. Co., Ill (ee)
Wal-Mar Corp., Ill (ee)
Washburn Wire Co., Phillipsdale Div., RI (q,bb,dd)
Weirton Steel Co., Div. of National Steel Corp., W.Va
(cc)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (o)
Western Iron & Foundry Co., Inc., Kan (o,z,bb,cc,dd)
Wheatland Tube Co., Pa
(ee)
Wickwire Bros., Inc., NY (bb,ff)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (w,z)
Wilson Steel & Wire Co., Ill (ff)
Wisconsin Steel Co., Div. of International Harvester Co., Ill (o,q)
Wycoff Steel Co., Pa (o,z)
Youngstown Sheet and Tube Co., Ohio (o,z,bb,cc,dd,ee,ff)

Steel, Carbon—Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Adirondack Steel Casting Co., NY

K E Y

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Allied Steel Castings Co., Ill
All-Metals Precision Casting Corp., NY
Alloy Cast Steel Co., Ohio
Alloy Precision Castings Co., Ohio
Alloy Steel & Metals Co., Calif
American Cast Iron Pipe Co., Ala
American Steel Foundries, Ill
Arneson Foundry Co., Wis
Arwood Precision Castings Corp., NY
Atlantic Foundry Co., Ohio
Atlantic Steel Castings Co., Pa
Austenal Co., Div. of Howe Sound Co., NY
Auto Specialties Mfg. Co., Mich
Bay City Electric Steel Casting Co., Mich.
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Birdsboro Steel Foundry & Machine Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Calumet Steel Castings Corp., Ind
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Commercial Steel Casting Co., Ohio
Crucible Steel Casting Co., Pa
Dayton Steel Foundry Co., Ohio
Eastern Malleable Iron Co., Del
Electric Steel Castings Co., Ind
Electric Steel Foundry Co., Ore
Electrocast Steel Foundry Co., Ill
Empire Foundry Co., Inc., Calif
Empire Steel Castings, Inc., Pa
Engineered Castings Div., American Brake Shoe Co., NY
Falk Corp., Wis
Farrel-Birmingham Co., Inc., Conn
Federal Steel Products Corp., Tex
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa
General Electric Co., Foundry Dept., NY
General Steel Castings Corp., Ill
Globe Steel Abrasive Co., Ohio
Glover Machine Works, Ga
Goslin Birmingham Mfg. Co., Inc., Ala
Grede Foundries, Inc., Wis
Gunite Foundries Corp., Ill
Hartford Electric Steel Corp., Conn
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Hughes Tool Co., Tex
Humphrey Castings, Inc., Calif
Illinois Precise Casting Co., Ill
Kay-Brunner Steel Products, Inc., Calif
LFM Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa —Ad p 402
Lectromelt Casting Div., Akron Standard Mold Co., Ohio
Liberty Foundry Co., Mo
Lincoln Iron Works, Vt
Los Angeles Steel Casting Co., Calif
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa
Manco Products, Inc., Mich
Massillon Steel Casting Co., Ohio
Mercast Mfg. Corp., Calif
Midwest Precision Castings Co., Ohio
Minneapolis Electric Steel Castings Co., Minn
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
Monroe Steel Castings Co., Mich
Montague Machine Co., Mass
National Iron Co., Minn
National Malleable & Steel Castings Co., Ohio
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
Ohio Steel Foundry Co., Ohio
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla
Olympic Steel Works, Wash
Omaha Steel Works, Neb
Pelton Steel Casting Co., Wis
Penn Steel Castings Co., Pa
Perfecto Cast, Calif
Picco, Inc., Calif
Pittsburgh Steel Foundry Corp., Pa
Posey Iron Works, Inc., Pa
Pratt & Letchworth Div., Dayton Malleable Iron Co., Inc., NY
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Quality Electric Steel Castings, Inc., Tex
Quincy Steel Casting Co., Mass
Racine Steel Castings Co., Wis
Reliance Steel Castings Co., Pa
Ross-Meehan Foundries, Tenn
St. Louis Steel Casting, Inc., Mo
Sandusky Foundry & Machine Co., Ohio
Sawbrook Steel Castings Co., Ohio
Scullin Steel Co., Mo
Sharpsville Steel Fabricators, Inc., Pa
Sivyer Steel Casting Co., Wis
Skookum Co., Inc., Ore
Sorbo-Mat Process Engineers, Mo
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Star Heel Plate Co., Inc., NJ
Strong Steel Foundry Co., NY
Superior Foundry, Inc., Ohio
Superior Steel & Malleable Castings Co., Mich
Swedish Crucible Steel Co., Mich
Texas Foundries, Inc., Tex
Texas Steel Co., Tex
Thys Co., Calif
Union Iron Works, Wash
Union Spring & Mfg. Co., Pa
Unitcast Corp., Ohio —Ad p 392
U.S. Pipe & Foundry Co., Ala
Utility Steel Foundry, Calif
Valley Steel Casting Co., Mich
Vascoloy-Ramet Corp., Ill
Vulcan Iron Works, Pa
Washington Iron Works, Wash
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Westlectric Castings, Inc., Calif
Worthington Corp., NJ

Steel, Heat and Corrosion Resistant

Acme Tube, Inc., NJ (ee)
Advance Stamping Co., Mich (dd)
Albraco Metals Co., NY (o,q,bb,ee,ff)
Alco Products, Inc., NY (q)
Allegheny Ludlum Steel Corp., Pa (o,q,w,z,bb,cc,dd,ee,ff)—Ad p 81
Alloy Metal Powders, Inc., NY (aa)
Alloy Metal Products, Inc., Iowa (o,q,w)
Alofs Mfg. Co., Mich (dd)
American Cast Iron Pipe Co., Ala (ee)
American Silver Co., NY (v,dd,ee,ff)
American Steel and Wire Div., U. S. Steel Corp., Ohio (ff)
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (bb, ff)
Arcos Corp., Pa (ff)
Aristoloy Steel Div., Copperweld Steel Co., Ohio (o,q)
Armco Steel Corp., Ohio (o,q,v,z,bb, cc,dd,ff)
Athenia Steel Div., National-Standard Co., NJ (dd)
Austenal Co., Div. of Howe Sound Co., NY (w)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)—Ad p 383
Bethlehem Steel Co., Pa (o,q,z,bb,cc, ee,ff)
Biddle Screw Products Co., Ind (bb)
Bishop, J. & Co. Platinum Works, Pa (ee)—Ad p 376
Brinkerhoff Brass & Bronze Works, Inc., NY (z,bb,cc)
Brush Beryllium Co., Ohio (v,dd)
Byers, A.M. Co., Pa (o,q,w,z,cc,dd)
Cannon-Muskegon Corp., Mich (w)
Carlson, G.O., Inc., Pa (o,z,cc)
Carpenter Steel Co., Pa (o,q,w,bb,dd, ff)
Carpenter Steel Co., Alloy Tube Div., NJ (ff)
Carpenter Steel Co., Webb Wire Div., NJ (ff)
Castle, A.M. & Co., Ill (o,q,z,cc,dd,ff)
Central Fabricators, Inc., Ohio (z,bb, cc,ee)
Chromalloy Corp., NY (cc)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (o,q,w,z,cc,dd, ee,ff)
Crucible Steel Co. of America, Pa (o,q,w,z,bb,cc,dd,ee,ff)—Ad p 33
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,z,bb,cc,dd,ff)
Curtiss-Wright Corp., Metals Processing Div., NY (ee)
Damascus Tube Co., Pa (ee)—Ad p 390
Dixon Sintaloy, Inc., Conn (o)
Driver, Wilbur B. Co., NJ (y,bb,dd,ff)—Ad p 153
Dudek & Bock Spring Mfg Co., Ill. (dd, ff)
Eastern Stainless Steel Corp., Md (z,cc,dd)—Ad pp 90-91
Eaton Mfg. Co., Reliance Div., Ohio (o,ff)
Edgcomb Steel & Aluminum Corp., NJ (o,z,cc,dd)
Electric Steel Foundry Co., Ore (o,q, w,z,bb,cc,dd,ee,ff)
Erskine Precision Wire Corp., Pa (ff)
Firth Sterling, Inc., Pa (o,q,bb,dd)
Frasse, Peter A. & Co., Inc., NY (o,bb,cc,dd,ee,ff)—Ad p 92
Fromson Orban Co., Inc., NY (ee)
Gary Steel Products Corp., Va (o,z,cc)
Green River Steel Corp., Ky (o,q,w)
Hamilton Watch Co., Precision Metals Div., Pa (v,cc,dd,ff)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (o, z,bb,dd,ee,ff)
Hexcel Products, Inc., Calif (v)
Hoeganaes Sponge Iron Corp., NJ (aa)—Ad p 422
Industrial Stainless Steels, Inc., Mass (o,q,z,bb,cc,dd,ee,ff)
Jessop Steel Co., Pa (o,q,z,cc,dd,ee)
Johnson, A. & Co., Inc., NY (ee)
Jones & Laughlin Steel Corp., Pa (o, q,cc,dd)
Joslyn Stainless Steels, Ill (o,q,w,bb, ff)
Kaiser Steel Corp., Calif (o,q,w,z,bb, cc,dd)
Kelsey-Hayes Co., Mich (o,q,z,cc)
Kinkead Industries, Inc., Ill (cc,dd)
Kirk & Blum Mfg Co., Ohio (z,cc)
Kolcast Industries Div., Thompson Products, Inc., Ohio (q,w)
Krueger Fabricating Co., Inc., Wis (cc)
Larson, Charles E. & Sons Inc., Ill (o)
Latrobe Steel Co., Pa (o,q,w)
Lockport Mfg. Co., Ill (z)
Lukens Steel Co., Pa (w,z)
Lundquist Tool & Mfg. Co., Inc., Mass (bb,cc,dd,ee,ff)
Makepeace, D.E. Div., Engelhard Industries Inc., Mass (o,dd,ee)
McCarter Iron Works, Inc., Pa (o,z, bb,cc)
McInnes Steel Co., Pa (o)
Mechanical Steel Tubing Corp., NY (ee)
Metal Forming Corp., Div. of Vanadium-Alloys Co., Ind (ee)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Michigan Seamless Tube Co., Mich (ee)
Midvale-Heppenstall Co., Pa (w)
Morrisville Foundry Co., Inc., Vt (bb)
Murray, A.B. Co., Inc., NJ (ee)
National Electric Products Corp., Pa (ee)
National Supply Co., Industrial Products Div., Calif (o,q,w)
National Tube Div., U.S. Steel Corp., Pa (ee)
National-Standard Co., Mich (dd,ff)
New Jersey Metals Co., NJ (w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Pencoyd Steel & Forge Corp., Pa (o, q,w)
Precision Tube Co., Inc., Pa (ee)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Ohio (o,q,w,z,bb,cc,dd,ee,ff)—Ad pp 82-83
Reynolds Aluminum Supply Co., Ga (o, z,bb,cc,dd,ee)
Riverside-Alloy Metal Div., H. K. Porter Co., Inc., NJ (bb,dd,ff)
Rodney Metals, Inc., NY (v,dd)
Rolled Alloys, Inc., Mich (o,q,z,bb, cc,dd,ee,ff)
Rolock, Inc., Conn (ff)
Rome Mfg. Div., Revere Copper & Brass Inc., NY (ee)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
Sandusky Foundry & Machine Co., Ohio (ee)
Sandvik Steel, Inc., NJ (dd,ee,ff)—Ad p 96
Service Steel Div., Van Pelt Corp., Mich (ee)
Seymour Mfg. Co., Conn (dd)
Sharon Steel Corp., Pa (q,w,z,cc,dd)—Ad p 86
Sharpsville Steel Fabricators, Inc., Pa (o,z,bb,dd)
Simonds Saw & Steel Co., Mass (o, cc)
Smith-Moon Steel Co., Kan (o,z,cc,dd)
Solar Steel Corp., Ohio (o,z)
Somers Brass Co., Inc., Conn (v,dd)
Stainless and Strip Div., Jones & Laughlin Steel Corp., Mich (o,q,w,bb,cc,dd,ff)—Ad pp 94-95
Stainless and Strip Div., Jones & Laughlin Steel Corp., Ohio (dd)—Ad pp 94-95
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (q,w)
Star Heel Plate Co., Inc., NJ (z,ff)
Sun Steel Co., Ill (cc,dd)
Superior Drawn Steel Co., Pa (o, bb,ff)
Superior Mfg. Co., Pa (dd,ff)
Superior Steel Corp., Pa (dd)
Superior Steel Div., Copperweld Steel Co., Pa (dd)

Superior Tube Co., Pa
(ee)—Ad p 421
Sylvania Electric Products, Inc., Parts Div., Pa
(ff)
Techalloy Co., Inc., Pa (v,bb,dd,ff)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (o,q,w,z,cc,dd,ff)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q,ee)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Uddeholm Co. of America, Inc., NY (bb,dd)
Ulbrich Stainless Steels Corp., Conn
(dd)—Ad p 88
Union Steel Corp., NJ (dd,ee)
United Screw & Bolt Corp., Ill (bb,cc,dd,ff)
U.S. Challenge & Challenge Co., Ill (bb)
U.S. Gasket & Shim Co., Ohio (cc,dd)
U. S. Steel Corp., Pa
(o,q,w,z,cc,dd,ee,)—Ad pp 84-85
U.S. Steel Supply Div., U.S. Steel Corp., Ill (o,q,z,cc,ee)
Universal-Cyclops Steel Corp., Pa (o,q,z,bb,cc,dd,ff)
Uniworld Research Corp. of America, Ohio (o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Vanadium-Alloys Steel Co., Pa (o,q,w,z,aa,bb,cc,ff)
Vulcan Rail & Construction Co., NY (o,dd,ee)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (o,q,z,bb,ff)
Walmet Alloys Co., Mich
Wall Tube & Metal Products Co., Tenn (ee)
Wallingford Steel Co. Conn (v,dd)
Washington Steel Corp., Pa (cc,dd)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
(o,q,w,z,bb,cc,dd,ee)—Ad p 97
Whitehead Metal Products Co., Inc., NY (z,bb,cc,dd)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (z)
Wisconsin Centrifugal Foundry Inc., Wis (ee)
Worcester Wire Works Div., National-Standard Co, Mass (ff)

Steel, Heat and Corrosion Resistant—Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Adirondack Steel Casting Co., NY
Aelco Foundries, Inc., Wis
Allegheny Ludlum Steel Corp., Pa
All-Metals Precision Casting Corp., NY
Alloy Engineering & Casting Co., Ill
Alloy Precision Castings Co., Ohio
Alloy Steel Casting Co., Pa
American Brake Shoe Co., NY
American Cast Iron Pipe Co., Ala
American Steel Foundries, Ill
Apex Steel Corp., Ltd., Calif
Arwood Precision Castings Corp., NY
Austenal Co., Div. of Howe Sound Co., NY
Beaver Valley Alloy Foundry Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Bonney-Floyd Co., Ohio
Brinkerhoff Brass & Bronze Works, Inc., NY
Calorizing Co., Pa
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Commercial Steel Casting Co., Ohio
Copper Alloy Corp., NJ
Crucible Steel Casting Co., Pa
Curtiss-Wright Corp., Metals Processing Div., NY
Dodge Steel Co., Pa
Donegal Steel Foundry Co., Pa
Duraloy Co., Pa
—Ad p 401
Duraloy Co., Pa
Duriron Co., Inc., Ohio
Electric Steel Foundry Co., Ore
Electro-Alloys Div., American Brake Shoe Co., Ohio
Empire Steel Castings, Inc., Pa
Engineered Castings Div., American Brake Shoe Co., NY
Fahralloy Co., Ill
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa
Frasse, Peter A. & Co., Inc., NY
General Alloys Co., Mass
General Electric Co., Foundry Dept., NY
Goslin Birmingham Mfg. Co., Inc., Ala.
Grede Foundries, Inc., Wis
Hanford Foundry Co., Calif
Hartford Electric Steel Corp., Conn
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Humphrey Castings, Inc., Calif
Illinois Precise Casting Co., Ill
Industrial Stainless Steels, Inc., Mass
Ingersoll-Rand Co., NJ
Janney Cylinder Co., Pa
Johnson, A. & Co., Inc., NY
Jones & Laughlin Steel Corp., Strip Steel Div., Ohio (dd)
Kay-Brunner Steel Products, Inc., Calif
Kolcast Industries Div., Thompson Products, Inc., Ohio
LFM Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa
—Ad p 402
Los Angeles Steel Casting Co., Calif
Manco Products, Inc., Mich
Massillon Steel Casting Co., Ohio
Michigan Steel Casting Co., Div. of Consolidated Foundries & Mfg. Corp., Mich
Midwest Precision Castings Co., Ohio
Minneapolis Electric Steel Castings Co., Minn.
Misco Precision Casting Co., Mich
National Malleable & Steel Castings Co., Ohio
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
National Supply Co., Industrial Products Div., Calif
Ohio Steel Foundry Co., Ohio
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla.
Perfecto Cast, Calif
Picco, Inc., Calif
Pittsburgh Steel Foundry Corp., Pa
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Rodney Metals, Inc., NY (v,dd)
Ross-Meehan Foundries, Tenn
Sandusky Foundry & Machine Co., Ohio
Sharpsville Steel Fabricators, Inc., Pa
Sivyer Steel Casting Co., Wis
Skookum Co., Inc., Ore
Stainless Foundry & Engineering, Inc., Wis
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Stanwood Corp., Ill
Star Heel Plate Co., Inc., NJ
Superior Foundry, Inc., Ohio
Symington-Gould Corp., NY
Texas Foundries, Inc., Tex
Texas Steel Co., Tex.
Thompson Products, Inc., Valve Div., Ohio
Union Iron Works, Wash
U.S. Pipe & Foundry Co., Ala
Uniworld Research Corp. of America, Ohio
Utility Steel Foundry, Calif
Vollrath Co., Contract Div., Wis
Wall Colmonoy Corp., Stainless Process Div., Mich
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Wisconsin Centrifugal Foundry, Inc., Wis

Steel, Low Alloy

Acme Tube, Inc., NJ (ee)
Acme-Newport Steel Co., Ky (z,cc,ee)
Advance Screw Products Co., Inc., Wis
Advance Stamping Co., Mich (dd)
Alan Wood Steel Co., Pa (o,q,w,z,cc,dd)
Alco Products, Inc., NY (q,aa)
Alloy Metal Products, Inc., Iowa (o,q,w)
Alofs Mfg. Co., Mich (cc,dd,ff)
Amalgamated Steel Corp., Ohio (o,bb)
American Cast Iron Pipe Co., Ala
(ee)
American Steel and Wire Div., U. S. Steel Corp., Ohio
(o,dd)
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (bb,ff)
Arcos Corp., Pa (ff)
Aristoloy Steel Div., Copperweld Steel Co., Ohio (o,q)
Armco Steel Corp., Ohio (z,cc,dd)
Armco Steel Corp., Sheffield Div., Mo (o,q,w,z,bb,cc,ff)
Arrow Metal Products Corp., NJ (cc)
Atlantic Steel Co., Ga (o)
Austenal Co., Div. of Howe Sound Co.,
Babcock & Wilcox Co., Tubular Products Div., Pa
(ee)—Ad p 383
Bethlehem Steel Co., Pa (o,q,z,bb,cc)
Biddle Screw Products Co., Ind (bb)
Bliss & Laughlin, Inc., Ill (o)
Burkhardt Steel Co., Colo (o,z,cc,dd)
Byers, A.M. Co., Pa (o,q,w,z)
California Metal Enameling Co., Calif (cc)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Pa (o,q,w,bb,dd,ff)
Castle, A.M. & Co., Ill (o,q)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (o,q,w,z,cc,dd,ee)
Connors Steel Div., H.K. Porter Co., Inc., Ala (o,q)
Crucible Steel Co. of America, Titanium & Vacuum Metals Product Div., Pa (o,q,w,bb,cc,dd)
Curtiss-Wright Corp., Metals Processing Div., NY (ee,ff)
Dixon Sintaloy, Inc., Conn (o)
Dudek & Bock Spring Mfg Co., Ill (dd,ff)
Eastern Rolling Mills, Inc., NY (cc,dd)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (z,cc)
Enterprise Wheel & Car Corp., Va (z,cc)
Finkl, A. & Sons Co., Ill (w)
Frasse, Peter A. & Co., Inc., NY
(o,z,bb,cc,dd,ee,ff)
Great Lakes Steel Corp., Div. of National Steel Corp., Mich (z,cc,dd)
Green River Steel Corp., Ky (o,q,w)
Hardy, Charles, Inc., N (aa)
Hayden Wire Works, Inc., Mass (o,bb,ff)
Higbie Mfg. Co., Mich (ee)
Hoeganaes Sponge Iron Corp., N J
(aa)—Ad p 422
Inland Steel Co., Ill (o,z,cc,dd)
Jones & Laughlin Steel Corp., Pa (o,q,z,cc,dd,ee,ff)
Kaiser Steel Corp., Calif (o,q,w,z,bb,cc,dd)
Kelsey-Hayes Co., Mich (o,q,z,cc)
Keystone Drawn Steel Co., Pa (q)
Kinkead Industries, Inc., Ill (cc,dd)
Larson, Charles E. & Sons Inc., Ill (o)
La Salle Steel Co., Ill (o)
Levinson Steel Co., Pa (cc)
Lincoln Steel Corp., Neb (cc)
Lukens Steel Co., Pa
(w,z)—Ad pp 76-77
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee)
McInnes Steel Co., Pa (o)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Mechanical Steel Tubing Corp., NY (ee)
Metal Forming Corp., Div. of Vanadium-Alloys Co., Ind (ee)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Michigan Seamless Tube Co., Mich (ee)
Midvale-Heppenstall Co., Pa (w)
Murray, A.B. Co., Inc., NJ (ee)
National Tube Div., U.S. Steel Corp., Pa (ee)
National-U.S. Radiator Corp., Plastic Metals Div., Pa (aa)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb)
Northwestern Steel & Wire Co., Ill (o,q,w,z,bb,ff)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Pencoyd Steel & Forge Corp., Pa (o,q,w)
Peninsular Steel Co., Mich (o,q,z)
Pittsburgh Forgings Co., Mich (o,q)
Rathbone Corp., Mass (o,bb)
Reliance Div., Eaton Mfg. Co., Ohio (o,ff)
Republic Steel Corp., Ohio
(o,q,w,z,bb,cc,dd,ee,ff)—Ad pp 82-83
Revere Copper & Brass, Inc., NY (ee)
Rodney Metals, Inc., NY (v,dd)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
St. Louis Steel Casting, Inc., Mo (n)
Sandusky Foundry & Machine Co., Ohio
(ee)
Sandvik Steel, Inc., NJ
(dd)
Sawhill Tubular Products, Inc., Pa (ee)
Scudder, E.J. Foundry & Machine Co., NJ (bb,ee)
Service Steel Div., Van Pelt Corp., Mich (ee)
Sharon Steel Corp., Pa
(q,w,z,cc,dd)
Sharpsville Steel Fabricators, Inc., Pa (o,z,bb,cc)
Simonds Saw & Steel Co., Mass (o,cc)
Smith-Moon Steel Co., Inc., Kan (o,z,cc)
Solar Steel Corp., Ohio (o,z)
Stainless and Strip Div., Jones & Loughlin Steel Corp., Ohio
(dd)—Ad pp 94-95
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (q,w)
Star Heel Plate Co., Inc., NJ (ee,ff)
Sun Steel Co., Ill (o,q,z,bb,cc,dd)
Superior Drawn Steel Co., Pa (o,bb,ff)
Superior Tube Co., Pa
(ee)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (o,q,w,z,cc,dd,ee)
Thomas Strip Div., Pittsburgh Steel Co., Pa (dd)
Thompson Wire Co., Mass (dd)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q,ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Uddeholm Co. of America, Inc., NY (bb)
Union Iron Works, Wash (cc)
Union Steel Corp., NJ (dd)
United Screw & Bolt Corp., Ill (bb,cc,dd,ff)
U. S. Steel Corp., Pa
(o,q,w,z,cc,dd)—Ad pp 84-85
U.S. Steel Supply Div., U.S. Steel Corp., Ill (o,z,cc,dd,ee)
Vanadium-Alloys Steel Co., Pa (o,q,w,z,aa,bb,cc,ff)
Washburn Wire Co., Phillipsdale Div., RI (q,bb,dd)
Weirton Steel Co., Div. of National Steel Corp., W.Va
(cc)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (o)
Wheelock, Lovejoy & Co., Inc., Mass (o,q,bb)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (w,z)
Wilder Mfg. Co., Inc., Calif (o,z,cc)
Wyckoff Steel Co., Pa (o,z)
Youngstown Sheet and Tube Co., Ohio (o,z,cc,dd,ee)

Steel, Low Alloy —Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Adirondack Steel Casting Co., NY
Allied Steel Castings Co., Ill
All-Metals Precision Casting Corp., NY
Alloy Cast Steel Co., Ohio
Alloy Precision Castings Co., Ohio
Alloy Steel & Metals Co., Calif
American Cast Iron Pipe Co., Ala
American Manganese Steel Div., American Brake Shoe Co., Ill
—Ad p 419
American Steel Foundries, Ill
Arwood Precision Castings Corp., NY
Atlantic Foundry Co., Ohio
Atlantic Steel Castings Co., Pa
Austenal Co., Div. of Howe Sound Co., NY
Auto Specialties Mfg. Co., Mich
Bay City Electric Steel Casting Co., Mich
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Birdsboro Steel Foundry & Machine Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Commercial Steel Casting Co., Ohio
Crucible Steel Casting Co., Pa
Dayton Steel Foundry Co., Ohio
Electric Steel Castings Co., Ind
Electric Steel Foundry Co., Ore
Electrocast Steel Foundry Co., Ill
Empire Foundry Co., Inc., Calif
Empire Steel Castings, Inc., Pa
Federal Steel Products Corp., Tex
General Electric Co., Foundry Dept., NY
General Steel Castings Corp., Ill
Glover Machine Works, Ga
Goslin Birmingham Mfg. Co., Inc., Ala
Grafton Foundry Co., Wis
Grede Foundries, Inc., Wis
Gunite Foundries Corp., Ill
Hartford Electric Steel Corp., Conn
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Hughes Tool Co., Tex
Humphrey Castings, Inc., Calif
Illinois Precise Casting Co., Ill
Jones & Laughlin Steel Corp., Pa
Kay-Brunner Steel Products, Inc., Calif
Kolcast Industries Div., Thompson Products, Inc., Ohio
Lebanon Steel Foundry, Pa
—Ad p 402
Lectromelt Casting Div., Akron Standard Mold Co., Ohio
Los Angeles Steel Casting Co., Calif
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa
Massillon Steel Casting Co., Ohio
Mercast Mfg. Corp., Calif
Midwest Precision Castings Co., Ohio
Minneapolis Electric Steel Castings Co., Minn
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
Monroe Steel Castings Co., Mich
National Iron Co., Minn
National Malleable & Steel Castings Co., Ohio
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
National Supply Co., Industrial Products Div., Calif
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla
Olympic Steel Works, Wash
Omaha Steel Works, Neb
Pelton Steel Casting Co., Wis
Perfecto Cast, Calif
Picco, Inc., Calif
Pittsburgh Steel Foundry Corp., Pa
Posey Iron Works Inc., Pa
Pratt & Letchworth Div., Dayton Malleable Iron Co., Inc., NY
Precision Founders, Inc., Calif
Quaker Alloy Casting Co.. Pa
Quality Electric Steel Castings, Inc., Tex
Racine Steel Castings Co., Belle City Malleable Div., Wis
Reliance Steel Castings Co., Pa
Ross-Meehan Foundries, Tenn
St. Louis Steel Casting, Inc., Mo
Sandusky Foundry & Machine Co., Ohio
Sawbrook Steel Castings Co., Ohio
Scudder, E.J. Foundry & Machine Co., NJ
Sharpsville Steel Fabricators, Inc., Pa
Sivyer Steel Casting Co., Wis
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Star Heel Plate Co., Inc., NJ
Strong Steel Foundry Co., NY
Superior Foundry, Inc., Ohio
Swedish Crucible Steel Co., Mich
Taylor-Wharton Co., Div. of Harsco Corp., NJ
Texas Foundries, Inc., Tex
Texas Steel Co., Tex
Union Iron Works, Wash
Union Spring & Mfg. Co., Pa
Unitcast Corp., Ohio
—Ad p 392
United Shoe Machinery Corp., Mass
U.S. Pipe & Foundry Co., Ala
Utility Steel Foundry, Calif
Valley Steel Casting Co., Mich
Vulcan Iron Works, Pa
Washington Iron Works, Wash
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Westlectric Castings, Inc., Calif
Worthington Corp., NJ

Steel, Specialty

(electrical, magnet, nitriding, etc.)

Acme-Newport Steel Co., Ky (cc)
Adirondack Steel Casting Co., NY
Allegheny Ludlum Steel Corp., Pa
(o,q,z,bb,ff)—Ad p 81
Alloy Metal Powders, Inc., NY (aa)
Amalgamated Steel Corp., Ohio (o,bb)
American Silver Co., Inc., NY (v, bb, ee,ff)
Armco Steel Corp., Ohio (o,q,v,z,bb,cc,dd,ee,ff)
Arnold Engineering Co., Ill (dd)
Atlantic Steel Co., Ga (o)
Austenal Co., Div. of Howe Sound Co., NY (w)
Brush Beryllium Co., Ohio
(v,dd)
Byers, A. M. Co., Pa (q,z)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Pa (o,q,w,bb,dd)
Chicago Development Corp., Md (aa)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Crucible Steel Co., of America, Pa
(o,q,w,z,bb,cc)—Ad p 33
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,z,bb,cc,dd,ff)
Edgcomb Steel & Aluminum Corp., NJ (o,cc,dd)
Green River Steel Corp., Ky (o,q,w)
Hamilton Watch Co., Precision Metals Div., Pa (v,cc,dd,ff)
Hoeganaes Sponge Iron Corp., NJ
(aa)—Ad p 422
Inland Steel Co., Ill (cc)
Johnston & Funk Titanium Corp., Ohio (w,bb,ff)
Jones & Laughlin Steel Corp., Pa (o,z,cc)
Kelsey-Hayes Co., Utica Metals Div., NY (o,q,w,z,bb,cc,dd,ff)
Larson Tool & Stamping Co., Mass (o)
La Salle Steel Co., Mo (o)
Latrobe Steel Co., Pa
(o,q,w)
Lukens Steel Co., Pa
(w,z)
Mallory-Sharon Metals Corp., Ohio
(cc)
Manganese Steel Forge Co., Pa (o,z,bb,cc,dd,ff)
McInnes Steel Co., Pa (o)
Metal Forming Corp., Div of Vanadium-Alloys Co., Ind (ee)
Midvale-Heppenstall Co., Pa (q,w)
National Supply Co., Pa (o,q)
National Supply Co., Industrial Products, Div., Calif (o,q,w)
National-Standard Co., Mich
(dd,ff)
Republic Steel Corp., Ohio
(o,q,w,z,bb,cc,dd,ee)
Ryerson, Joseph T. & Son, Inc., Ill (o)
Sandvik Steel, Inc., NJ
(o,bb,dd)
Sharon Steel Corp., Pa
(cc)
Simonds Saw and Steel Co., Mass (cc,dd)
Stulz-Sickles Co., NJ (o,q,z,bb)
Superior Steel Corp., Pa (dd)
Sylvania Electric Products Inc., Parts Div., Pa
(ff)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q,ee)
Universal-Cyclops Steel Corp., Pa (o,q,z,bb,cc,dd,ff)
Utica Metals Div., Kelsey-Hayes Co., NY (o,q,w,z,bb,cc,dd,ff)
Vanadium-Alloys Steel Co., Pa (o,q,w,z,aa,bb,cc,ff)
Vascoloy-Ramet Corp., Ill
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
(o,q,v,w,z,bb,cc,dd,ee)

Steel, Specialty —Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Allegheny Ludium Steel Corp., Pa
All-Metals Precision Casting Corp., NY
Alloy Precision Castings Co., Ohio
American Steel Foundries, Ill
Arwood Precision Castings Corp., NY
Austenal Co., Div. of Howe Sound Co., NY
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Crobalt, Inc., Mich
Crucible Steel Casting Co., Pa

Curtiss-Wright Corp., Metals Processing Div., NY
Electric Steel Foundry Co., Ore
General Electric Co., Foundry Dept., NY
General Steel Castings Corp., Ill
Grede Foundries, Inc., Wis
Hica, Inc., La
Howard Foundry Co., Ill
Humphrey Castings, Inc., Calif
Janney Cylinder Co., Pa
Johnston & Funk Titanium Corp., Ohio
Kay-Brunner Steel Products, Inc., Calif
Kolcast Industries, Div., Thompson Products, Inc., Ohio
LFM Mfg. Co., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa
Los Angeles Steel Casting Co., Calif
Manco Products, Inc., Mich
Mercast Mfg. Corp., Calif
Midwest Precision Castings Co., Ohio
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
National Supply Co., Industrial Products Div., Calif
Overmyer Mould Co., Inc., Ind
Perfecto Cast, Calif
Picco, Inc., Calif
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Quality Electric Steel Castings, Inc., Tex
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Star Heel Plate Co., Inc., NJ
Stulz-Sickles Co., NJ
Swedish Crucible Steel Co., Mich
Taylor-Wharton Co., Div. of Harsco Corp., NJ
Texas Foundries, Inc., Tex
United Shoe Machinery Corp., Mass
U.S. Pipe & Foundry Co., Ala
Uniworld Research Corp. of America, Ohio
Utility Steel Foundry, Calif
Vanadium-Alloys Steel Co., Pa
Wall Colmonoy Corp., Stainless Process Div., Mich
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Wisconsin Centrifugal Foundry, Inc., Wis

Steel, Tool and Die

A & A Die Casting Co., Calif (o,z,bb,cc)
Able Tool & Engineering Co., Ill (z)
Advance Stamping Co., Mich (o,z,bb)
Albraco Metals Corp., NY (o,q,bb)
Allegheny Ludlum Steel Corp., Pa
(o,q,z,bb,ff)—Ad p 81
Alofs Mfg. Co., Mich (o,z,bb)
Amalgamated Steel Corp., Ohio (o,bb)
Anchor Drawn Steel Co., Div. of Vanadium Alloys Steel Co., Pa (bb,ff)
Austenal Co., Div. of Howe Sound Co., NY (w)
Bethlehem Steel Co., Pa (o,q)
Biddle Screw Products Co., Ind (gg)
Braeburn Alloy Steel Corp., Pa (o,q)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Pa (o,q,w,bb,dd,ff)
Columbia Tool Steel Co., Ill (o,q,w,bb)
Crucible Steel Co. of America, Pa
(o,q,w,z,bb,cc)—Ad p 33
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,w,z,bb,cc,dd,ff)
Dahlin, C.A. Co., Ill (o,z,cc,dd)
Delaware Tool Steel Corp., Del (o)
Edgcomb Steel & Aluminum Corp., NJ (o,q,w,bb)
Finkl, A. & Sons Co., Ill (w)
Firth Sterling, Inc., Pa (o,q,bb,dd)
Forg, Peter Mfg. Co., Mass (cc)
Frasse, Peter A. & Co., Inc., NY (o)
Green River Steel Corp., Ky (o,q,w)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (o,z,bb)
Heller Tool Co., Ohio (o)
Inshield Die & Stamping Co., Ohio (o)
Jessup Steel Co., Pa (o,q,z,cc,dd)
Jones & Laughlin Steel Corp., Pa (o,z,bb)
Kinkead Industries, Inc., Ill (o,z,bb)
Larson, Charles E. & Sons, Inc., Ill (o)
Latrobe Steel Co., Pa
(o,q,w)—Ad p 93
Lundquist Tool & Mfg. Co., Inc., Mass (o,z,bb)
Metal Forming Corp., Div of Vanadium-Alloys Co., Ind (ee)
Midvale-Heppenstall Co., Pa (q,w)
National Supply Co., Industrial Products Div., Calif (o,q,w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Norwalk Powdered Metals, Inc., Conn (aa)
Ormond Mfg., Co., Inc., NJ (cc,dd,ff)
Pencoyd Steel & Forge Corp., Pa (o,q,w)
Peninsular Steel Co., Mich (o,q,z)
Pittsburgh Tool Steel Wire Co., Pa (o,bb)
Republic Steel Corp., Ohio
(o,q)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,bb,cc)
Sandvik Steel, Inc., NJ
(o)
Sharpsville Steel Fabricators, Inc., Pa (bb)
Simonds Saw & Steel Co., Mass (o,cc)
Solar Steel Corp., Ohio (o,bb)
Superior Tube Co., Pa
(ee)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q)
Uddeholm Co. of America, Inc., NY (o,q)
q,z,bb,cc,dd,ff)
Universal-Cyclops Steel Corp., Pa (o,
Vanadium-Alloys Steel Co., Pa (o,q,w,z,aa,bb,cc,ff)
Vulcan-Kidd Steel Div., H.K. Porter Co. Inc., Pa (o,q,w,bb,ff)
Walmet Alloys Co., Mich
Wheelock, Lovejoy & Co., Inc., Mass (o,q,bb)
Wilder Mfg. Co., Inc., Calif (o,bb)
Ziv Steel & Wire Co., Ill (o,q)

Steel, Tool and Die —Castings

Albraco Metals Corp., NY
Allegheny Ludlum Steel Corp., Pa
All-Metals Precision Casting Corp., NY
Alloy Precision Casting Co., Ohio
American Foundry & Machine Div., Eimco Corp., Utah
Apex Steel Corp., Ltd., Calif
Arwood Precision Castings Corp., NY
Atlantic Steel Castings Co., Pa
Austenal Co., Div of Howe Sound Co., NY
Bay City Electric Steel Casting Co., Mich
Beaver Valley Alloy Foundry Co., Pa
Bone Engineering Corp., Calif
Carondelet Foundry Co., Mo
Crucible Steel Co. of America, Pa
Crucible Steel Casting Co., Pa
Curtiss-Wright Corp., Metals Processing Div., NY
Empire Steel Castings, Inc., Pa
General Electric Co., Foundry Dept., NY
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Illinois Precise Casting Co., Ill
Kolcast Industries Div., Thompson Products Inc., Ohio
LFM Mfg. Co., Sub. of Rockwell Mfg. Co., Kan
Manco Products, Inc., Mich
Midwest Precision Castings Co., Ohio
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Industrial Products Div., Calif
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Ross-Meehan Foundries, Tenn
Star Heel Plate Co., Inc., NJ
Swedish Crucible Steel Co., Mich
Vanadium-Alloys Steel Co., Pa
Westinghouse Electric Corp., Materials Mfg. Dept., Pa

Strip

(see specific material)

Strippable Coatings

(see Organic Coatings)

Styrene

(see Polystyrene)

Styrene-Butadiene Rubber

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NJ
(bb,cc,dd,ee)
American Synthetic Rubber Corp., NY (p)
Anderson Assoc., Inc., Ohio (y)
Auburn Plastics, Inc., NY (bb,cc,dd)
Auburn Rubber Co., Inc., Ind (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Borden Co., Chemical Div., NY (p)
Capac Mfg. Corp., Mich (y,cc)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Continental Rubber Works, Pa (bb,cc,dd,ee)
Copolymer Rubber and Chemical Corp., La (p)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Dyna-Therm Chemical Corp., Calif
(p)
Electrofilm, Inc., Calif (t)
Faultless Rubber Co., Ohio (u,y,bb,ee)
Firestone Tire & Rubber Co., Ohio (p)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
Geauga Industries Co., Ohio (y,bb,dd)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Goodrich-Gulf Chemicals Inc., Ohio
(p)—Ad p 254
Goodyear Tire & Rubber Co., Chemical Div., Ohio (p)
Goshen Rubber Co., Inc., Ind
(y)
Heresite & Chemical Co., Wis (p)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd)
Koppers Co., Inc., Pa (p)
Maloney, F.H. Co., Tex (y)
Marbon Chemical Div., Borg-Warner Corp., Ind
(p,u,x,y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Parker, Stearns & Co., Inc., NY (cc,dd)
Phillips Chemical Co., Okla (p)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,cc,dd,ee)
Roth Rubber Co., Ill
(y,cc)
Rubatex Div., Great American Industries Inc., Va (u)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Shell Chemical Corp., NY (p)
Sheller Mfg. Corp., Mich (u)
Southern Plastics Co., SC (bb,cc,dd,ee)
Stockwell Rubber Co., Inc., Pa (y,bb,cc,dd)
Technical Specialties Co., NY (dd)
Texas-U.S. Chemical Co., NY (p)—Ad pp 233-238
Toyad Corp., Pa (u)
Trostel, Albert Packing, Ltd., Wis (y)
United Rubber & Chemical Co., W.Va (p)
U.S. Rubber Co., NY (p)
U.S. Rubber Co., Kem-Blo Dept., Conn (u)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Westlake Plastics Co., Pa (t,bb,cc,dd)
Williams-Bowman Rubber Co., Ill (y,bb,cc)

Superalloys

(see Nickel; Cobalt; Chremium)

Synthetic Fibers

(see specific polymer)

Tantalum and Its Alloys

Alpha Metals, Inc., NJ (v,cc,dd)
American Silver Co., NY (v,dd,ee,ff)
Belmont Smelting & Refining Works, Inc., NY (aa)
Bishop, J. & Co. Platinum Works, Pa (ee)
Bridgeport Brass Co., Conn (ee)—Ad p 152
Columbia-National Corp., Mass (w)
Damascus Tube Co., Pa (ee)—Ad p 390
Fansteel Metallurgical Corp., Ill (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad pp 158, 159
Foote Mineral Co., Pa (aa)
General Plate Div., Metals & Controls Corp., Mass (v,dd)
Hamilton Watch Co., Precision Metals Div., Pa (v,dd)
Hardy, Charles, Inc., NY (aa)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (o,bb,cc,dd,ff)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Kawecki Chemical Co., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Kennametal, Inc., Pa (o,v,aa,dd,ff)—Ad p 301
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (dd)
Mallory, P.R. & Co., Inc., Ind (bb,dd)
Mallory-Schwarzkopf Metals, Inc., NY (o,v,w,z,bb,cc,dd,ee,ff)
Metals & Controls Corp., Mass (v,dd,ff)
National Research Corp., Mass (v,w,aa,bb,cc,ee,ff)
Nuclear Metals, Inc., Mass (w,bb,dd,ee)
Oregon Metallurgical Corp., Ore (w)
Shieldalloy Corp., NJ (aa)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (w,aa)—Ad pp 144-145
Universal Cyclops Steel Corp., Pa (o,q,z,cc)
Wah Chang Corp., NY (v,aa,bb,dd,ff)—Ad p 146
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)

Tapes, Adhesive

American Tape Co., Mich
Avery Label Co., Decorative Products Div., Ohio
Angier Adhesives Div., Interchemical Corp., Mass
Beck, I. & Sons, Inc., NY
Coating Products, Inc., NJ
Connecticut Hard Rubber Co., Conn
Cycleweld Div., Chrysler Corp., Mich
Durable Rubber Products Co., Ill
Dutch Brand Div., Johns-Manville Corp., Ill
Electro Technical Div., Sun Chemical Corp., NJ
Enflo Corp., NJ
Foamade Industries, Mich
Foss Mfg. Co., Plastics Div., Id
Hampton Mfg. Co., NY
Insulation Mfrs. Corp., Ill
Interchemical Corp., NY
Interchemical Corp., Finishes Div., NJ
Johns-Manville Corp., NY
Kinkead Industries, Inc., Ill
Lundquist Tool & Mfg. Co., Inc., Mass
Magnesium Co. of America, Ind
Mystik Adhesive Products, Inc., Ill
Narmco Resins & Coatings Co., Calif
Nicolet Industries, Inc., NY
Permacel, Inc., NJ
Peterson, D.J. Co., Wis
Presstite-Keystone Engineering Products Co., Mo
Respro Div., General Tire & Rubber Co., RI
Reynolds Aluminum Supply Co., Ga
Rubber & Plastics Compound Co., Inc., NY
Shell Chemical Corp., NY
Superior Plastics, Inc., Ill
Technical Tape Corp., NY

Teflon

(see Fluorocarbons)

Terne Plate

(see Precoated Metals)

Tetrafluoroethylene

(see Fluorocarbon)

Tin and Its Alloys

Allied Research Products, Inc., Md (n)—Ad p 327
Alpha Metals, Inc., NJ (n,o,q,v,w,aa,bb,cc,dd)
American Metal Climax, Inc., NY (w,aa)
American Smelting & Refining Co., NY (n,o,w)
Anchor Metal Co., Inc., NY (w,aa)
Arcos Corp., Pa (ff)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,aa,cc,dd,ff)
Caspers Tin Plate Co., Ill (cc,dd)
Cerro de Pasco Sales Corp., NY (w)—Ad p 154
Crown Metal Co., Wis (n,ee,ff)
Division Lead Co., Ill (o,v,w,cc,dd,ee,ff)
Dixon Sintaloy, Inc., Conn (o)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Farrelloy Co., Pa (aa,ff)
Glidden Co., Chemicals-Pigments-Metals Div., Md (aa)—Ad p 391
Greenback Industries, Inc., Mich (aa)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hi-Grade Alloy Corp., Ill (n,o,v,w,ee)
Hodgson Foundry Co., Ill (n)
Indium Corp. of America, NY (dd,ff)
Johnston Foil Div., Standard Packaging Corp., Mo (v,cc)
Korhumel Steel and Aluminum Co., Ill (z,dd)
McGean Chemical Co., Ohio (n,o,aa)
Metal & Thermit Corp., NJ (n,w,aa)
Metallizing Engineering Co., Inc., NY (ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ (aa)—Ad p 415
Modern Plating Corp., Ill (n)
National Lead Co., NY (n,o,q,w,z,aa,bb,cc,dd,ee)
Nesor Alloy Products Co., NJ (ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Pittsburgh Smelting & Refining Co., Pa (o,w)
Presswork, Inc., Mich (cc)
Republic Metals Co., Inc., NY (n,o,v,w,cc,ee,ff)
Revere Copper & Brass, Inc., Foil Div., NY (v)
River Smelting & Refining Co., Ohio (o)
Rotometals, Calif (o,v,w,aa)
Sall, George Metals Co., Inc., Pa (w)
Stevens, Frederic B., Inc., Mich (n)
Udylite Corp., Mich (n)

Tinplate

(see Precoated Metals)

Titanium and Its Alloys

Alpha Metals, Inc., NJ (v)
American Silver Co., NY (v,dd,ee,ff)
Belmont Smelting & Refining Works, Inc., NY (aa)—Ad p 159
Bishop, J. & Co. Platinum Works, Pa (ee)
Bridgeport Brass Co., Conn (ee)—Ad p 152
Carpenter Steel Co., NJ (ee)
Central Fabricators, Inc., Ohio (z,bb,cc,ee)
Chicago Development Corp., Md (aa)
Crucible Steel Co. of America, Pa (o,q,w,z,bb,cc,dd,ee,ff)—Ad p 33
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,v,z,bb,cc,dd,ee,ff)
Damascus Tube Co., Pa (ee)—Ad p 390
Driver-Harris Co., NJ (v,dd)
du Pont de Nemours, E. I. & Co., Inc., Del (w)
Electric Steel Foundry Co., Ore (o,q,w,bb,ee)
Foote Mineral Co., Pa (o,bb)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum Sales, Inc., Calif (o,q,w,bb,ee)
Hexcel Products, Inc., Calif (v)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
King Laboratories, Inc., NY (w,aa)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd)
Mallory, P.R. & Co., Inc., Ind (o,z,bb,cc,dd,ee)
Mallory-Sharon Metals Corp., Ohio (o,q,w,z,bb,cc,dd,ee,ff)—Ad p 151
Metal Hydrides, Inc., Mass (aa)
Metal & Thermit Corp., NJ (w)
Metals & Controls Corp., Mass (v,cc,dd)
Metals Disintegrating Co., Inc., NJ (aa)—Ad p 415
Michigan Seamless Tube Co., Mich (ee)
National Lead Co., NY (o,q,w,z,bb,cc,dd,ee,ff)
National-Standard Co., Mich (ff)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Nuclear Metals, Inc., Mass (w,bb,dd,ee)
Oregon Metallurgical Corp., Ore (o,q,w)
Pioneer Aluminum, Inc., Calif (z)
Republic Steel Corp., Ohio (o,w,z,cc,ee)
Rigidized Metals Corp., NY (cc,dd)
Rodney Metals, Inc., NY (v,dd)
Superior Steel Corp., Pa (dd)
Superior Tube Co., Pa (ee)
Techalloy Co., Inc., Pa (dd,ff)
Titanium Metals Corp. of America, NY (o,q,z,aa,bb,cc,dd)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Ullmann, Inc., Wis (o,ee)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (aa)—Ad pp 144-145
United International Research, Inc., NY (aa)
Vanadium Corp. of America, NY (w)
Worcester Wire Works Div., National-Standard Co., Mass (ff)
Youngstown Welding & Engineering Co., Ohio (ee)

Tool Steels

(see Steel)

Transfer Moldings

(see Moldings)

Trifluorochloroethylene

(see Fluorocarbon)

Tubing, Pipe

Ace Plastic Co., NY (k,l)
Acme Tube, Inc., NJ (a,b,c,g)
Acme-Newport Steel Co., Ky (g)
Albert Pipe Supply Co., Inc., NY (a,g)
Albright Son & Co., Pa (g)
Allegheny Ludlum Steel Corp., Pa (g)
Allied Tube Corp., Pa (a,g)
Aluminum Co. of America, Pa (a,e)
Amco Plastic Pipe Co., Calif (k)
American Agile Corp., Ohio (k)
American Brass Co., Sub. of Anaconda Co., NY (b)

Suppliers of Materials

American Cast Iron Pipe Co., Ala
(c,f,g)—Ad p 374
American Manganese Steel Div., American Brake Shoe Co., Ill
(g)
American Molding Co., Calif (k)
American Nickel Alloy Mfg. Corp., NY (f)
American Pipe & Construction Co., Ore (g)
American Plastics Corp., NY (k)
American Reed Co., Inc., Mass (a)
American Smelting & Refining Co., NY (d)
American Silver Co., NY (b,f,g,h)
Ampco Metal, Inc., Wis (b)
Anaconda Metal Hose Div., American Brass Co., Sub. of Anaconda Co., Conn (a,b,g,k)
Anchor Plasties Corp., NY (k)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Armco Steel Corp., Ohio (g)
Arvin Industries, Inc., Ohio (a,g)
Atlantic India Rubber Works, Inc., Ill (m)
Atlantic Steel Co., Ga (a,g)
Atlas Mineral Products Co., Pa (k)
Auburn Plastic Engineering, Ill (k)
Avon Tube Div., Higbie Mfg. Co., Mich (g)
Babcock & Wilcox Co., Tubular Products Div., Pa
(c,g)—Ad p 383
Badger Aluminum Extrusions, NY (a)
Barium Steel Corp., NY (g)
Bassons Industries Corp., NY (k)
Benada Aluminum Products Co., Ohio (a)
Bethlehem Steel Co., Pa (g)
Bishop, J. & Co. Platinum Works, Pa
(f,g)—Ad p 376
Bohn Aluminum & Brass Corp., Mich (a)
Borden Co., Chemical Div., NY (k)
Brainard Steel Div., Sharon Steel Corp., Ohio (g)
Bridgeport Brass Co., Conn
(a,b,f,h)—Ad p 152
Brinkerhoff Brass & Bronze Works, Inc., NY (a,b,f,g)
Broadway Mfg. Co., Wis (c,f,g)
Bundy Tubing Co., Mich (f,g)
Bunker Hill Co., Calif (d)
Burkhardt Steel Co., Colo (g)
Busada Mfg. Co., NY
(c,g)—Ad p 394
Byers, A. M. Co., Pa (c,k)
Cadillac Plastic & Chemical Co., Mich (k,l)
Calfibe Co., Inc., Calif (k)
Carlon Products Corp., Ohio (k)
Carpenter Steel Co., Alloy Tube Div., NJ (g)
Cartwright, R. Tube Products Co., Mich (a,b,e,f,g)
Celluplastic Corp., NJ (k)
Channel Master Corp., NY (a)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (b)
Chicago Gasket Co., Ill (k)
Clayton Mark & Co., Ill (g)
Cleveland Steel Specialty Co., Inc., Ohio (g)
Clifton Conduit Corp., Md (g)
Colonial Alloys Co., Pa (a)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works Co., Ohio (k)
Colorado Fuel and Iron Corp., Colo (g)
Columbia-Geneva Steel Div., U. S. Steel Corp., Calif (g)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (k,m)
Connecticut Hard Rubber Co., Conn (m)
Continental Can Co., Inc., NY (k)
Continental Copper & Steel Industries, Inc., NY (a,b,c,e,f,g,h)
Continental Rubber Works, Pa (m)
Continuous Cast Products Dept., American Smelting & Refining Co., NJ
(b)
Copper and Brass Sales, Inc., Mich (a,b,e)
Cornell and Underhill, Inc., NJ (a,c,g)
Corson Industries, Pa (a)
Crane Co., Ill (k)
Crescent Plastics, Inc., Ind (k)
Crucible Steel Co. of America, Pa
(f,g,h)
Crucible Steel Co. of America, Titanium & Vacuum Metals Products Div., Pa (f,g,h)
CrystalX Corp., Pa (k)
Curbell, Inc., NY (k,l,m)
Curtiss-Wright Corp., Metals Processing Div., NY (g,h)
Damascus Tube Co., Pa
(f,g,h)—Ad p 390
Daubert Chemical Co., Ill (m)
Defiance Metal Products Co., Ohio (g)
Detroit Float & Stamping Co., Mich (b)
Division Lead Co., Ill (d)
Dixie Aluminum Corp., Ga (a)
Dixie Plastics Mfg. Co., La (k)
Dixon Corp., RI (k)
Dormont Mfg. Co., Pa (a,b,c,e)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Drawn Metal Tube Co., Conn (b)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Easton Plastic Products Co., Inc., Pa (k)
Eclipse Plastic Industries, Inc., Fla (k)
Edgcomb Steel & Aluminum Corp., NJ (a)
Electric Steel Foundry Co., Ore (g,h)
Electronic Parts Mfg. Co., NJ (f)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a,b,f,g)
Empire Metal Co., NY (d)
Ethylene Chemical Corp., NJ (l)
Evans Metal Co., Ga (d)
Eynon-Dakin Co., Mich (a,b,c,f,g)
Fibercast Co., Div., of Youngstown Sheet and Tube Co., Okla (l)
FitzSimons Mfg. Co., Mich (g)
Flexaust Co., Div. of Callahan Mining Co., Inc., NY (m)
Flexonics Corp., Ill (g)
Florence Pipe Foundry & Machine Co., NJ (c)
Formed Tubes, Inc., Mich (g)
Fox Products Co., Pa (a)
Franklin Plastics, Inc., Pa (k)
Frasse, Peter A. & Co., Inc., NY
(a,g)
Fromson Orban Co., Inc., NY (a,b,f,g)
Garlock Packing Co., NY (k)
Gates Rubber Co., Colo (k)
Geauga Industries Co., Ohio (m)
General Extrusions, Inc., Ohio
(a)
General Motors Corp., Rochester Products Div., NY
(g)—Ad p 409
General Plastics Corp., Ohio (k)
Genesee Laboratories, Inc., NY (k)
Gering Products, Inc., NJ (k)
Glass Laboratories, NY (k)
Goodrich, B.F., Industrial Products Co., Ohio (k)
H & H Tube & Mfg. Co., Mich (b)
H-P Products, Inc., Ohio (g)
Hall Mfg. Co., NJ (k)
Hartwell, H.N. & Son, Inc., Mass (k)
Harvey Aluminum Sales, Inc., Calif (a,h)
Hawkridge Bros. Co., Mass (a)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f)
Hays Mfg. Co., Pa (l)
Hazledine, E.T. Co., Ind (g)
Heil Process Equipment Corp., Ohio (k)
Hi-Grade Alloy Corp., Ill (d)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Hungerford Plastics Corp., NJ (k)
Hydrawlik Co., NJ (k,m)
Imco Container Corp., Mo (k)
Industrial Pipe & Supply Co., Ill (g)
Industrial Plastic Fittings Co., Ohio (k)
Industrial Synthetics Corp., NJ (k)
International Nickel Co., Inc., NY (f)
Jackson Steel Products, Inc., NY (a,b,g)
Jarl Extrusions, Inc., NY
(a)
Jessop Steel Co., Pa (g)
Jet Specialties Co., Inc., Calif (k)
Johnson Metal Hose, Inc., Conn (b,f)
Johnson Plastic Corp., Ohio (k,m)
Johnson Rubber Co., Ohio (m)
Jones & Laughlin Steel Corp., Pa (g)
Jordan-Rogers Co., Calif (k)
Judsen Rubber Works, Inc., Ill (m)
K S H Plastics, Inc., Mo (k)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kaiser Steel Corp., Calif (g)
Kemmore Machine Products, Inc., NY (b)
Kensico Tube Co., NY (b)
Kleiner Metal Specialties, Inc., NJ (g)
Koehler Mfg. Co., Mass (g)
Kraloy Plastic Pipe Co., Inc., Calif (k)
Kroh Wagner, Ill (a,g)
Laclede Steel Co., Mo (g)
Lamtex Industries, Inc., NY (l)
Langseokamp, F.H. Co., Ind (a,b)
Leach & Garner Co., Mass (b,f)
Lee Rubber & Tire Corp., Pa (m)
Lewin-Mathes Co., Mo (b)
Lewis & Saunders, NH (a,b,g)
Linderme Tube Co., Ohio (a,b)
Lock Joint Tube Co., Inc., Ind (g)
Lunn Laminates, Inc., NY (l)
Lus-Trus Corp., Mich (k)
Luzerne Rubber Co., NJ (k,l)
MacKenzie-Walton Co., RI (b)
Magline Inc., Mich (a,e)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,e,g)
Manufacturers Corp., Ohio (k)
Manufacturers & Fabricators, Inc., Ohio (f)
Mechanical Rubber Products Co., NY (l)
Mechanical Steel Tubing Corp., NY (a,g)
Meier Screw Products & Mfg. Co., Mich (a,b,c,e,g)
Melco Wire Products, Calif (a)
Metal Forming Corp., Div. of Vanadium-Alloys Co., Ind (a,c,f,g)
Metal Goods Corp., Mo (a,b,f,g)
Midland Pipe & Supply Co., Ill (b,c,g)
Midvale-Heppenstall Co., Pa (g)
Minnesota Mining & Mfg. Co., Minn (k,l)
Missouri Boiler & Sheet Works, Mo (g)
Moore Drydock Co., Calif (g)
Morse, Fred W. Co., RI (a)
Moxness Products, Inc., Wis
(m)
Mueller Brass Co., Mich
(b)—Ad p 397
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Nalge Co., Inc., NY (k)
Narragansett Boiler Works, Inc., RI (g)
National Copper & Smelting Co., Ohio (b)
National Electric Products Corp., Pa (g)
National Galvanizing Co., Pa (g)
National Gasket & Washer Mfg. Co., Inc., NY (k,l,m)
National Lead Co., NY (a,b,d)
National Lead Construction Co., Inc., NJ (d)
National Supply Co., Pa (g)
National Tube Div., U.S. Steel Corp., Pa (g)
National Tube Div., U.S. Steel Corp., Pa (k)
National Vulcanized Fibre Co., Del
(k,l)
New England Tape Co., Inc., Mass (k)
Newage Industries, Inc., Pa (k)
Nikoh Tube Co., Ill (g)
Noera Mfg. Co., Conn (b,g)
Nuclear Metals, Inc., Mass (a,b,c,e,f,g,h)
Ohio Seamless Tube Div., Copperweld Steel Co., Ohio (g)
Ohio Steel Foundry Co., Ohio (f)
Olds Alloys Co., Calif (b,d,f)
Olin Mathieson Chemical Corp., Aluminum Div., NY
(a)
Olin Mathieson Chemical Corp., Metals Div., NY (a)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Oregon Metallurgical Corp., Ore (h)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g,h,j)
Parker Metal Goods Co., Mass (a,g)
Parker, Stearns & Co., Inc., NY (m)
Parker-Street Castings Co., Ohio (c)
Pencoyd Steel & Forge Corp., Pa (c,g)
Penn Brass & Copper Co., Pa (b)
Penn Extrusion Corp., Pa (a)
Perfex Plastics, Inc., Ill (k)
Pfister Aluminum Corp., NJ (a)
Phoenix Iron & Steel Co., Pa (g)
Pittsburgh Steel Co., Pa (j)
Pittsburgh Tube Co., Pa (g)
Plastex Co., Ohio
Plastic Pipe & Tube Corp., Calif (k)
Plastic Process Co., Inc., Calif (k)
Polyform Plastics Corp., NY (k)

Polymer Corp. of Pennsylvania, Sub. of Polymer Corp., Pa
(k)

Porter, William Co., Calif (l)
Precision Extrusions, Inc., Ill (a)
Precision Tube Co., Inc., Pa (a,b,f,g)
Pressed Steel Co., Pa (f)
Prince Rubber Co., Inc., NY (k,l)
Pyramid Moldings, Inc., Ill (g)
Pyramid Plastics, Inc., Ill (k,m)
Raybestos-Manhattan, Inc., NJ (m)

Raybestos-Manhattan, Inc., Adhesives Div., Conn
(k)

Reading Tube Corp., NY (b)
Reflin Co., Calif (l)
Reinhold Engineering & Plastics Co., Calif (k)
Reliance Plastic & Chemical Corp., NJ (k)
Ren Plastics, Inc., Mich (l)
Replac Corp., Ohio (k,l,m)

Republic Steel Corp., Ohio
(g)

Republic Steel Corp., Steel & Tubes Div., Ohio (f,g,h)
Resistoflex Corp., NJ (k)
Revere Copper & Brass, Inc., NY (a,b,g)
Rex Corp., Mass (k)
Reynolds Aluminum Supply Co., Ga (a,g,b)
Reynolds Metals Co., Va (a)

Rigidized Metals Corp., NY
(a,g)

Roll Formed Products Co., Ohio
(a,g)

Rolled Alloys, Inc., Mich (f,g)
Rolock, Inc., Conn (f)
Rome Turney Radiator Co., NY (a,b,g)
Roth Steel Products Co., Ohio (g)
Rotometals, Calif (d)
Rowland Products, Inc., Conn (k)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)

Sandusky Foundry & Machine Co., Ohio
(b,f,g)

Sandvik Steel, Inc., NJ (g)
Sanford Plastics Corp., NY (k)
Saran Lined Pipe Co., Mich (g)
Sawhill Tubular Products, Inc., Pa (f,g)
Schwab Plastics Corp., Mich (k,m)

Scovill Mfg. Co., Mill Products Div., Conn
(b)

Service Steel Co., Mich (g)
Shamban, W.S. & Co., Ind (k)
Sharpsville Steel Fabricators, Inc., Pa (b,g)
Shaw-Kendall Engineering Co., Ohio (a,b,c,f,g)
Shanango Furnace Co., Centrifugally Cast Products Div., Ohio (b,c,f)
Shoe Form Co., NY (k)
Sierra Electric Corp., Calif (k)
Skyline Industries, Pa (k)
Small Tube Products, Inc., Conn (b)
Snyder, M.L. & Son, Inc., Pa (k)
Solar Steel Corp., Ohio (g)
South River Metal Products Co., Inc., NJ (a,e)
Southern Aluminum Finishing Co., Inc., Ga (a)
Southern Fabricating Co., Inc., Ala (g)
Southern Plastics Co., SC (k,m)
Southwestern Plastic Pipe Co., Tex (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Spiral-Glas Pipe Co., NJ (k)
Spuck Iron & Foundry Co., Mo (g)
Standard Metals Corp., Mass (b,f)
Standard Products Co., Mich (m)
Standard Tube Co., Mich (g)
Star Heel Plate Co., Inc., NJ (g)
Stockwell Rubber Co., Inc., Pa (k,m)
Stokes Molded Products, Div., Electric Storage Battery Co., NJ (k)
Summerill Tubing Co. Div., Columbia Steel & Shafting Co., Pa (g)
Sunlite Plastics, Inc., Wis (k)

Superior Tube Co., Pa
(c,f,g,h)—Ad p 421

Supplex Co., Div. of American Hard Rubber Co., NJ (k,m)
Surprenant Mfg. Co., Mass (k)
Swepco Tube Corp., NJ (f)
Synthane Corp., Pa (l)
Taylor Fibre Co., Pa (l)
Technical Specialties Co., NY (m)
Tennessee Coal and Iron Div., U.S. Steel Corp., Ala (g)
Texas Aluminum Co., Tex (a)
Thermoid Div., H. K. Porter Co., Pa (k,l,m)
Thompson Pipe & Steel Co., Colo (c,f,g)
Timken Roller Bearing Co., Ohio (g)
Titanium Metals Corp. of America, NY (h)
Tompkins Products, Mich (a)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (f,g,h)
Triangle Conduit & Cable Co., Inc., NJ (b,k)
Trim Alloys, Inc., Mass (a)
Tube Distributors Co., Inc., NY (c,e,f,g,h)
Tube Methods, Inc., Pa (c,f,g)
Tube Reducing Corp., NJ (f,g,h)
Udylite Corp., Mich (k)
Uniform Tubes, Inc., Pa (a,b,f,g)
Union Steel Corp., NJ (g)
U.S. Flexible Tubing Co., Ill (g)

U. S. Gasket Plastics Div., Garlock Packing Co., NJ
(k,l)

U.S. Rubber Co., Mechanical Goods Div., Ind (k)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
U.S. Stoneware Co., Ohio (k)
U.S. Valve & Mfg. Co., Calif (g)
United Wire & Supply Corp., RI (a,b)
Universal Converting Corp., Mass (a)
Vanamatic Co., Ohio (g)
Van Huffel Tube Corp., Ohio (a,b,g)
Van Pelt Corp., Service Steel Div., Mich (f,g,h)
Viking Copper Tube Co., Ohio (b)
Viplax Products Corp., NJ (k)
Visking Corp., Plastics Div., Ind (k)
Vogt Mfg. Corp., NY (k)
Vulcan Metal Products, Inc., Ala (a)
Vulcan Rail & Construction Co., NY (a,c,g)
Wall Tube & Metal Products Co., Tenn (b,f,g)
Wallace Tube Co., Div. of Wallace Supplies Mfg. Co., (a,b,g)
Wallingford Steel Co., Conn (g)
Wal-Mar Corp., Ill (a,b,c,e,g)
Waterman Industries, Inc., Calif (a,b)
Weiskittel, Harry C. Co., Inc., Md (c)
Welding Apparatus Co., Ill (a,f)
Wells, A.H. & Co., Inc., Conn (b)

Western Felt Works, Ill
(l,m)

Westlake Plastics Co., Pa (k,l,m)

Wheatland Tube Co., Pa
(g)—Ad p 400

Wheeling Steel Corp., Va (g)

White Metal Rolling & Stamping Corp., NY
(a,e)

Whitehead Metal Products Co., Inc., NY (a,b,f,g,h)

Williams-Bowman Rubber Co., Ill
(l,m)

Wolverine Tube Div., Calumet & Hecla, Inc., Mich
(a,b,g)—Ad p 403

Woolf Aircraft Products, Inc., Mich (a,b,f,g)
World Plastics, NY (k)

Yardley Plastics Co., Ohio
(k)—Ad p 400

Youngstown Mfg., Inc., Ohio (a)
Youngstown Sheet and Tube Co., Ohio (g)
Youngstown Welding & Engineering Co., Ohio (a,f,h)

Tungsten

American Metal Climax, Inc., NY (aa)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Associated Engineering & Mfg. Corp., NJ (o,aa,bb,cc,dd,ff)

Belmont Smelting & Refining Works, NY
(aa)

Cleveland Tungsten, Inc., Ohio (aa, bb)
Electronic Parts Mfg. Co., Inc., NJ (bb,ee,ff)
Elmet Div., North American Philips Co. Inc., Me (w,aa,bb,ff)

Fansteel Metallurgical Corp., Ill
(n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad pp 158, 159

Fromson Orban Co., Inc., NY (ff)
General Electric Co., Lamp Metals & Components Dept., Ohio (o,q,w,aa,bb,cc,dd,ff)

Gibson Electric Co., Pa
(aa)

Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)

Kennametal, Inc., Pa
(o,bb)—Ad p 301

Kinkead Industries, Inc., Ill (o)
Mallory-Schwarzkopf Metals, Inc., NY (o,v,w,z,bb,cc,dd,ee,ff)
Molybdenum Corp. of America, Pa (o,w,z,aa,bb,cc,dd)
Nuclear Metals, Inc., Mass (w,bb,dd,ff)
Reduction & Refining Co., NJ (q,w,aa,bb,ff)
Shieldalloy Corp., NJ (aa)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (w,aa,bb,ff)

Union Carbide Metals Co., Div. of Union Carbide Corp., NY
(aa)—Ad pp 144-145

Universal-Cyclops Steel Corp., Pa (o,q,z,cc)

Wah Chang Corp., NY
(n,aa,bb,cc,ff)—Ad p 146

Westinghouse Electric Corp., Materials Mfg. Dept., Pa
(o,q,v,w,z,bb,cc,dd,ee)

Upset Forgings

(see Forgings)

Ureas

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p,x,y)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p,y)

American Cyanamid Co., Plastics & Resins Div., NY
(p,u)—Ad pp 231-232

American Viscose Corp., Pa (y)
Archer-Daniels-Midland Co., Minn (p)
Bakelite Co., Div. of Union Carbide Corp., NY (p,x)
Borden Co., Chemical Div., NY (p)
Catalin Corp. of America, NY (p,x)
Chemical Process Co., Calif (x)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Ohio (u)
Dunnican Asso., NJ (y)

du Pont de Nemours, E. I. & Co., Inc., Del
(p)

Dyna-Therm Chemical Corp., Calif
(p)

Fluoro-Plastics Inc., Div. of Flexrock Co., Pa (bb,cc)
Gordon Chemicals, Inc., Del (y)
Grigoleit Co., Ill (p,s)
Kurz Kasch, Inc., Ohio (y)
Luminous Resins, Inc., Ill (y)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc)
Monsanto Chemical Co., Plastics Div., Mass (p)
Muehlstein, H. & Co., Inc., NY (p,y)
Nopco Chemical Co., NJ (p)
Omni Products Corp., NY (p)
Reichhold Chemicals, Inc., NY (p,x)
Robot Devices, Inc., Va (p,u,y)
Sylvan Plastics, Inc., Pa (y)
Synco Resins, Inc., Conn (p)
Texas Glass Fiber Corp., Tex (y)

Urethane Elastomers

Acushnet Process Co., Mass
—Ad p 250

Adhesive Products Corp., NY (x)
American Latex Products Co., Calif
American Rubber Products Corp., Ind (u,cc,dd)
Brown Rubber Co., Inc., Ind (u)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (p,u,x,y)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Continental Rubber Works, Pa (bb,cc,dd,ee)
Dayton Rubber Co., Ohio (p,u,x,y,bb,cc,dd,ee)
Disogrin Industries, Inc., NY (bb,cc)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)

du Pont de Nemours, E. I. & Co., Inc., Del
(v)

Faultless Rubber Co., Ohio (u)
Flexible Tubing Corp., Conn (ee)
Foam Products, Inc., Pa (u)
Foamade Industries, Mich (u,x,y,cc,dd)
General Electric Co., Plastics Dept., Ill (u)
General Plastics Mfg. Co., Wash (u,cc)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Hewitt-Robins, Inc., Conn (u,cc)
Isocyanate Products, Inc., Del (p,u)
Maloney, F.H. Co., Tex (x,y)
Marblette Corp., NY
Mobay Chemical Co., Pa (p,u,x,y)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Pelron Corp., Ill (p,u,x,y)
Prince Rubber Co., Inc., NY (bb,cc)

Reynolds Chemical Products Co., Mich
(p,u,x)—Ad p 258

Schwab Plastics Corp., Mich (u)
Scott Paper Co., Foam Div., Pa (u)
Sheller Mfg. Corp., Mich (u)
Technical Specialties Co., NY (dd)
Thermoid Div., H. K. Porter Co., Pa (u)
Thiokol Chemical Corp., NJ (p,y)
Thombert, Inc., Iowa (bb,cc)

Toyad Corp., Pa (t,u)
Trostel, Albert Packing, Ltd., Wis (y)
U.S. Rubber Co., NY (p)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Works, Ill (y,cc,dd,ee)
Witco Chemical Co., Ill (p,u)

Urethane Plastics

Adhesive Products Corp., NY (x)
Alcylite Plastics & Chemical Corp., Calif (p,u)
American Latex Products Corp., Calif
American Rubber Products Corp., Ind (u,cc,dd)
Atlas Mineral Products Co., Pa (u)
Atlas Powder Co., Del (u)
Burkart, F. Mfg. Co., Div. of Textron Inc., Mo (u)
Cadillac Plastic & Chemical Co., Mich (x,y,bb,cc,dd)
Chemical Coatings & Engineering Co., Inc., Pa (p,u,x,y)
Columbus Coated Fabrics Corp., Ohio (u)
Crest Chemical Industries Corp., NY (u)
CrystalX Corp., Pa (u)
Dayton Rubber Co., Ohio (p,u,x,y,bb,cc,dd,ee)
Disogrin Industries, Inc., NY (bb,cc)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (u,y)
du Pont de Nemours, E. I. & Co., Inc., Del (u)
Electro Chemical Engineering & Mfg. Co., Pa (u, cc)
Englander Co., Inc., Industrial Products Div., Md (u)
Foam Products, Inc., Pa (u)
Foamade Industries, Mich (u,x,y,cc,dd)
Foss Mfg. Co., Plastics Div., Id (u)
Fry Plastics Co., Calif (u)
Furane Plastics, Inc., Calif (x,y)
General Plastics Mfg. Co., Wash (u, cc)
General Tire & Rubber Co., Ind (u)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Glidden Co., Paint Div., Ohio (p,u)
Hadley Bros.-Uhl Co., Mo (u)
Hewitt-Robins, Inc., Conn (u,cc)
Interchemical Corp., Finishes Div., NJ (u)
Isocyanate Products, Inc., Del (p,u)
Luminous Resins, Inc., Ill (y)
Maloney, F.H. Co., Tex (y)
Mobay Chemical Co., Pa (p,u,x,y)
Nesbitt Industries, Inc., Ill (u)
Nopco Chemical Co., NJ (u,cc)
Paeco Rubber Co., Inc., Ohio (y,dd,ee)
Pelron Corp., Ill (p,x,y)
Permacel, Inc., NJ (u)
Prince Rubber Co., Inc., NY (bb,cc)
Reichhold Chemicals, Inc., NY (u)
Richardson Co., NY (bb,cc,ee)
Rubber Corp. of America, NY (u)
Russell Reinforced Plastics Corp., NY (u)
Schenectady Varnish Co., Inc., NY (p)
Schwab Plastic Corp., Mich (u)
Scott Paper Co., Foam Div., Pa (u)
Sheller Mfg. Corp., Mich (u)
Southern Plastics Co., NC (bb,cc,dd,ee)
Strick Plastics Co., Pa (u)
Thiokol Chemical Corp., NJ (p,u,x,y)
Toyad Corp., Pa (u)
United Shoe Machinery Corp., Mass (t,u)
U.S. Rubber Co., Conn (p,u,x,y)
Witco Chemical Co., Ill (p,u)
Woodall Industries, Inc., Mich (u)

Vacuum Formed Parts

(see Moldings, Sheet)

Vacuum Metallizing

(see Metallized Coatings)

Vanadium

American Metal Climax, Inc., NY (o)
American Nickel Alloy Mfg. Corp., NY (w)
Belmont Smelting & Refining Works, Inc., NY (aa)
Bridgeport Brass Co., Conn (ee)
Chace, W.M. Co., Mich (cc,dd)
Chicago Development Corp., Md (aa)
General Plate Div., Metals & Controls Corp., Mass (v)
Hardy, Charles, Inc., NY (aa)
Magnesium Elektron, Inc., NY (w,aa)
National-Standard Co., Mich (ff)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Nuclear Metals, Inc., Mass (w,bb,ee)
Shieldalloy Corp., NY (aa)
Union Carbide Metals Co., Div. of Union Carbide Corp., NY (w,z,aa,bb)—Ad pp 144-145
Vanadium Corp. of America, NY (o,v,z,bb,cc,dd,ee,ff)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)

Varnishes

(see Organic Coatings)

Vinyls

Adhesive Products Corp., NY (x)
Albany Novelty Mfg. Co., Mass (t)
Albert Pipe Supply Co., Inc., NY (ee)
Alcylite Plastics & Chemical Corp., Calif (p,y)
Alpha Plastics, Inc., NJ (bb,ee)
Alpha Wire Corp., NY (ee)
Amercoat Corp., Calif (cc)
American Agile Corp., Ohio (bb,cc,dd,ee)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)—Ad pp 240-241
American Molding Powder & Chemical Co., NY (y)
American Products Mfg. Co., Inc., La (p)
Atlas Mineral Products Co., Pa (bb,cc,dd,ee)
Auburn Plastic Engineering, Ill (cc)
Auburn Plastics, Inc., NY (y,bb,cc,dd,ee)
Automotive Rubber Co., Inc., Mich (u,y,cc)
Avery Label Co., Decorative Products Div., Ohio (t)
Bakelite Co., Div. of Union Carbide Corp., NY (p,t,u,y,bb)
Bamberger, Claude P., Inc., NJ (p,y)
Bischoff Chemical Corp., NY (u)
Blacher, B., NY (t)
Blaco Mfg. Co., Ohio (t)
Blank, Arthur & Co., Inc., Mass (t,cc)
Blossom Mfg. Co., Inc., NY (t,cc)
Borden Chemical Co., Resinite Dept., Calif (t,y,bb,cc,dd,ee)
Bradley & Vrooman Co., Ill
Brown Rubber Co., Inc., Ind (u)
Byers, A.M. Co., Pa (bb,cc,ee)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (u)
Carroll, J.B. Co., Ill (cc)
Carroll Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Cary Chemicals, Inc., NJ (p)
Celanese Plastics Co., Div. of Celanese Corp. of America, NJ (p)—Ad pp 219-226
Chemical Coatings and Engineering Co., Pa (x,y)
Chemical Products Corp., RI (x,y)
Clad-Rex Corp., Ill (t)
Colonial Art Co., Inc., Mass (cc)
Colonial Plastics Mfg. Co., Div. of Van Dorn Iron Works Co., Ohio (bb,cc,dd)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Ohio (p)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (ee)
Columbus Coated Fabrics Corp., Ohio (t,u,cc)
Comco Plastics, Inc., NY (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc)
Conneaut Rubber & Plastics Co., Div. of U.S. Stoneware Co., Ohio (y,bb,cc,dd)
Cordo Chemical Corp., Conn (y)
Crest Chemical Industries Corp., NY (u)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Curbell, Inc., NY (cc)
Dapol Plastics, Inc., Mass (y)
Davis, Joseph Plastics Co., NJ (t,bb)
Dennis Chemical Co., Mo (y)
Designers Metal Corp., Ill (cc)
Diamond Alkali Co., Ohio (p,y)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Douglas & Sturgess, Calif (y)
Dow Chemical Co., Plastics Div., Mich (p,y)—Ad p 239
Durable Formed Products, Inc., NY (cc,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E. I. & Co., Inc., Del (y,cc)
Dura Flex Co., Calif (t,cc)
Dura Plastics of New York, Inc., NY (cc)
Dyna-Therm Chemical Corp., Calif (p)
Elastomer Chemical Corp., NJ (y)
Electric Steel Foundry Co., Ore (bb,cc,dd,ee)
Electro Chemical Engineering & Mfg. Co., Pa (t)
Eljay Corp., Md (bb,cc,dd,ee)
Elm Coated Fabrics Co., Inc., NY (t,x)
Escambia Chemical Corp., NY (p)
Firestone Plastics Co., Pa (s,t)
Flexfirm Products, Calif (s)
Flexible Tubing Corp., Conn (ee)
Franklin Glue Co., Ohio (p)
Fry Plastics Co., Calif (cc)
Fuller, H.B. Co., Minn (x)
Fullerton Mfg. Co., Calif (y)
Galigher Co., Utah (bb,cc,dd,ee)
Geauga Industries Co., Ohio (bb,dd)
General Gasket Co., Inc., Conn (cc)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
General Tire & Rubber Co., Chemical Div., Ohio (p)
General Tire & Rubber Co., Textileather Div., Ohio (x)
Genesee Laboratory, Inc., NY (ee)
Gering Products, Inc., NJ (y,bb,ee)
Goodrich, B.F. Co., Sponge Products Div., Conn (u)
Goodrich, B.F. Chemical Co., Ohio (p,y)
Goodrich, B.F. Industrial Products Co., Ohio (t,bb,cc,dd,ee)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (p)
Gossett and Hill Co., Ill (p,x,y)
Great American Industries Inc., Rubatex Div., Va (u)
H & R Industries, Pa (bb,cc,dd,ee)
Hartwell, H. N. & Son, Inc., Mass (bb,cc,ee)
Haskelite Mfg. Corp., Mich (cc,dd)
Haveg Industries, Inc., Del (bb,cc,ee)
Heil Process Equipment Corp., Ohio (x)
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
Interchemical Corp, NY (u,y)
Interchemical Corp., Finishes Div., NJ (u)
Jet Specialties Co., Inc., Calif (bb,dd,ee)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc. Ky (p)
K S H Plastics, Inc., Mo (bb,cc,dd)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (t,bb,cc,dd,ee)
Knight, Maurice A., Ohio (cc)
Kuss, R.L. & Co., Inc., Ohio (t)
Laminated Plastex Corp., Ohio (x,cc)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc)
Maloney, F.H. Co., Tex (y)
Mannesmann-Easton Plastic Products Co., Inc., Pa (bb,ee)
Masland Duraleather Co., Pa (t,cc)
Mayon Plastics, Minn (ee)
Mono-Sol Corp., Ind (t,u)
Monsanto Chemical Co., Organic Chemicals Div., Mo (p)
Monsanto Chemical Co., Plastics Div., Mass (p,t,y)
Moore, Samuel & Co., Ohio (ee)
Morningstar-Paisley, Inc., NY (y)
Munray Products Div., Fanner Mfg. Co., Ohio (p,x,y)
Nalge Co., Inc., NY (ee)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
National Polymer Products Inc., Sub. of Polymer Corp., Pa
(y)
National Starch Products Inc., Structural Products Div., NY (p)
National Tube Div., U.S. Steel Corp., Pa (ee)
Naugatuck Chemical Div., U. S. Rubber Co., Conn (p,t,u,x,y,cc)
New England Tape Co., Inc., Mass (u,y,bb,cc,dd)
Newage Industries, Inc., Pa (ee)
Nixon Nitration Works, NJ (cc)
Omni Products Corp., NY (p,t,y,cc)
Ormond Mfg. Co., Inc., NJ (cc,dd)
O'Sullivan Rubber Corp., Va (cc)
O'Sullivan Rubber Corp., Plastics Div., Va (t)
Pawling Rubber Corp., NY (bb,dd,ee)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Permacel, Inc., NJ (ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Plast-Ad Mfg. Co., Inc (cc)
Polo Plastics Co., Wis (t)
Poly Resins, Calif (p)
Premier Thermo Plastics Co., Ky (y)
Prince Rubber Co., Inc., NY (bb, cc,ee)
Pyramid Plastics, Inc., Ill (bb,dd,ee)
Pyrosil, Inc., Ohio (u,ee)
Quelcor, Inc., Pa (t)
Rand Rubber Co., NY (p,t,x)
Raybestos-Manhattan, Inc., Plastics Products Div., Conn
(x)
Reliance Plastic & Chemical Corp., NJ (bb,dd)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,ee)
Resistoflex Corp., NJ (bb,cc)
Respro Div., General Tire & Rubber Co. (t,cc)
Reynolds Chemical Products Co., Mich
(p,x,y)
Reynolds Metals Co., Va (t)
Rezolin, Inc., Calif (t)
Ross & Roberts, Inc., Conn (t)
Rowland Products, Inc., Conn (bb,dd, ee)
Rubber Corp. of America, NY (p,t,u, y,cc)
Rubber & Plastics Compound Co.; Inc., NY (cc)
Russell Mfg. Co., Conn (s)
Saran Lined Pipe Co., Mich (bb,cc,ee)
Schwab Plastic Corp., Mich (u,bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Seaman Products, Calif (t,cc)
Seiberling Rubber Co., Plastics Div., Ohio (bb,cc)
Shawinigan Resins Corp., Mass (p)
Sheller Mfg. Corp., Mich (y)
Snyder, M.L. & Son, Inc., Pa (cc,ee)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd)
Stockwell Rubber Co., Inc., Pa (y,bb, cc,dd)
Sun Steel Co., Ill (t,cc)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,dd)
Supplex Co., Div. of Amerace Corp., NJ (y,dd,ee)
Synco Resins, Inc., Conn (p)
Texas Plastic Development Corp., Tex (bb)
Toyad Corp., Pa (u)
Union Carbide Plastics Co., Div. of Union Carbide Corp., NY (p,s,u,y)
United Shoe Machinery Corp., Mass (p,u)
U. S. Rubber Co., NY (p,y)
U. S. Stoneware Co., Ohio (cc,ee)
Varflex Corp., NY (ee)
Visking Corp., Plastics Div., Ind (t)
Vogt Mfg. Corp., NY (bb,dd)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (dd,ee)
Watson-Standard Co., Pa (u,y)
Western Plastics Corp., Neb (bb,dd, ee)
Whitehead Metal Products Co., Inc., NY (cc,ee)
Woodall Industries, Inc., Mich (cc)
World Plastics, NY (bb,cc,dd)
Wyatt's Plastics, Inc., Tex (bb,cc, dd,ee)

Vinylidene Chloride

(see Vinyls)

Vulcanized Fibre

Ace Plastic Co., NY (bb,cc)
Baer, N.S. Co., NJ (bb,cc,dd,ee)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd)
Colonial Kolonite Co., Ill (bb,cc,ee)
Comco Plastics, Inc., NY (bb,cc,dd, ee)
Commercial Plastics & Supply Corp., NY (bb,cc)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Coyne & Paddock, Inc., NY (cc)
Curbell, Inc., NY (bb,cc,ee)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Electrofilm, Inc., Calif (t)
Insulation Mfrs. Corp., Ill (bb,cc,dd, ee)
Iten Fibre Co., Ohio (s,bb,cc,dd,ee)
Laminated Plastex Corp., Ohio (x,cc)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
National Vulcanized Fibre Co., Del
(bb,cc,dd,ee)—Ad p 226
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Philrus Products Co., NJ (bb,cc,dd, ee)—Ad p 194
Spaulding Fibre Co., Inc., NY
(bb,cc,dd,ee)—Ad p 251
Staver Co., Inc., NY (cc,dd)
Taylor Fibre Co., Pa
(bb,cc,dd)—Ad p 227
Thombert, Inc., Iowa (cc,dd)
Westlake Plastics Co., Pa (bb,cc,dd, ee)
Wilmington Fibre Specialty Co., Del (bb,cc)

Welding Rods and Electrodes

(see Filler Metals)

Weldments

Abalon Precision Mfg. Corp., NY (a,b, c,g)
Acme Precision Products, Inc., Ohio (a,f,g)
Acorn Sheet Metal Mfg. Co., Inc., Ill (g)
Adams, I.G. Metalware Co., Mo (g)
Albert Pipe Supply Co., Inc., Foundation Div., NY (g)
Alco Products, Inc., NY (a,b,f,g)
Allis-Chalmers Mfg. Co., Wis. (a,f,g)
Alloy Products Corp., Wis
(a,f,g,h)—Ad p 408
Almco Steel Products Corp., Ind (a,b, c,g)
Aluminum Co. of America, Pa (a)
Amalgamated Steel Corp., Ohio (g)
American Brake Shoe Co., NY (b)
American Car & Foundry Div., ACF Industries, Inc., NY (a,e,g)
American Cast Iron Pipe Co., Ala
(g)
American Machine & Foundry Co., Cleveland Welding Div., Ohio (a,c, f,g,h)
American Metal Products Co., Mich (a,g)
American Pipe & Construction Co., Ore (a,g)
American Sheet Metal Works, Inc., Conn (a,g)
American Welding and Mfg. Co., Ohio (a,f,g,h)
Ampco Metal, Inc., Wis (b)
Anderson, O.L. Co., Inc., Mich (a,b,c, d,g)
Armor Metal Products Co., Ohio (a,g)
Atlas Steel Construction Co., NY (a, b,c,g)
Automotive Rubber Co., Inc., Mich (a, c,e,g)
Baldwin-Lima-Hamilton Corp., Eddystone Div., Pa (a,g)
Barclay Mfg. Co., Ind (c)
Beatty Machine & Mfg. Co., Ind (g)
Behringer Metal Works, Inc., NJ (a,g)
Beloit Iron Works, Wis (c,g)
Bergen Point Iron Works, NY (a,b,c,f, g,h)
Bethlehem Steel Co., Pa (g)
Biersach & Niedermeyer Co., Wis (a, b,c,g)
Blaw-Knox Co., Pa (a,g)
Blickman, S. Inc., NJ (a,b,c,f,h)
Brandt, Charles T Inc., Md (a,b,e, f,g)
Brinkerhoff Brass & Bronze Works, Inc., NY (a,b,c,f,g)
Brooks & Perkins, Inc., Mich
(a,e,g,h)
Burkhardt Steel Co., Colo (c,g)
Butler Mfg. Co., Mo (a,g)
Caldwell, W.E. Co., Ky (a,g)
Central Fabricators, Inc., Ohio (a,b, c,f,g,h)
Clarksville Foundry & Machine Works, Tenn (a,c)
Cleveland Steel Specialty Co., Ohio (g)
Combined Industries Co., NY (a,b,c, e,f)
Combustion Engineering, Inc., Ill (a, b,g)
Commercial Shearing & Stamping Co., Ohio (g)
Composite Forgings, Inc., Mich (g)
Continental Copper & Steel Industries Inc., NY (a,b,c,e,f,g,h)
Cornell and Underhill, Inc., NJ (a,g)
Darby Corp., Kan (a,f,g)
Dare Products, Inc., Mich (g)
Day Co., Minn (a,g)
Dixie Bronze Co., Ala (b)
Dolin Metal Products, Inc., NY (g)
Dow Chemical Co., Dow Metal Products Co. Div., Mich (e)
Downington Iron Works, Pa (c,g)
Dravo Corp., Pa (a,g)
Dresser Mfg. Div., Dresser Industries, Inc., Pa (g)
Electric Auto-Lite Co., Champlain & Mulberry Sts., Ohio (g)
Electric Steel Foundry Co., Ore (g)
Emerson-Sack-Warner Corp., Mass (a, f,g)
Enterprise Wheel & Car Corp., Va (a, g)
Evans, George Corp., Ill (g)
Everard Tap & Die Corp., NY (a,g)
Falk Corp., Wis (g)
Falstrom Co., NJ (a,b,c,d,e,f,g,h,J)
Farwell Metal Fabricating, Minn (a,c, e,f,g)
Federal Machine and Welder Co., Ohio (g)
Fitzgibbons Boiler Co., Inc., NY (c)
Foster Wheeler Corp., NY (a,f,g)
Gary Steel Products Corp., Va (a,g)
General Alloys Co., Mass (b,f)
General American Transportation Corp., Ill (a,c,g)
General American Transportation Corp., Plate & Welding Div., Ill. (a,f,g)
General Cable Corp., NY (g)
Glasby J.P. Mfg. Co., Inc., NJ (a,c, e,f,g)
Goslin Birmingham Mfg. Co., Inc., Ala (b,f,g)
Graver Tank & Mfg. Co., Inc., Ind (a,f,g)
Greene, G.G. Corp., Pa (g)
Hardy, Mfg. Corp., Ind (g)
Hazledine, E.T. Co., Ind (g)
Hibben & Co., Ill (a,g)
Hicks Corp., Mass (a,b,g)
Hobbs, Clinton E. Co., Mass (c,g)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Ideal Can Co., Mass (a,c,g)
Indus Corp., Ind (a,g)
Industrial Equipment Co., Ohio (a,g)
Industrial Pipe & Supply Co., Ill (g)
Industrial Precision Products, Ill (a, c)
Ingalls Iron Works Co., Ala (c,g)
Ingersoll Products Div., Borg-Warner Corp., Ill (g)
Inland Mfg. Co., Neb (g)
Interlake Mfg. Co., Mich (g)
International Nickel Co., Inc., NY (f)
Irvington Form & Tank Corp., NY (a, b,g)
Irwin-Sensenich Corp., Pa (g)
K-D Mfg. Co., Tex (c,g)
Kaiser Steel Corp., Calif (g)
Kelsey-Hayes Co., Mich (g)
Kewaunee Engineering Corp., Wis (c)
King, Alfred B. Co., Conn (a,b,c,d,f,g)
King Fifth Wheel Co., Pa (g)
Koven, L.O. & Bro., Inc., NJ (a,g)
Krueger Fabricating Co., Inc., Wis (a, b,c,e,g)
LFM Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan (g)
Langsenkamp, F.H. Co., Ind (a,b)
Larkin Specialty Mfg. Co., Calif (a, b,g)
Lawrence, L. Co., Inc., NJ (a,b,c,e, f,g,h,J)
Leader Iron Works, Inc., Ill (a,b,c, f,g)
Levinson Steel Co., Pa (g)
Lincoln Steel Corp., Neb (g)
Littleford Bros. Inc., Ohio (a,c,f,g)
Lockport Steel Fabricators, Inc., Ill (a,f,g)
Loeffler, J.M. Co., Machine & Brass Works, Pa (a,b,c)
Lukens Steel Co., Pa
(a,b,e,f,g,h)
Machine Products Corp., Ohio (a,b,c f,g)
Magline, Inc., Mich (a,e)
Magnesium Co. of America, Ind (a,e)
Mahon, R.C. Co., Mich (a,g)
Manganese Steel Forge Co., Pa (g)
Manufacturers & Fabricators, Inc., Ohio (f,g)
Manufacturers Service, Inc., Ohio (a, b,g)

Mayville Metal Products Co., Wis (g)
McDowell-Wellman Cos., Ohio (g)
McGregor-Michigan Corp., Mich (c,f,g)
McLanahan & Stone Corp., Pa (g)
McNally Pittsburg Mfg. Co., Kan (a,c,g)
Midvale-Heppenstall Co., Pa (g)
Midwest Piping Co., Inc., Mich (g)
Missouri Boiler & Sheet Works, Mo (g)
Moore Dry Dock Co., Calif (g)
Morrisville Foundry Co., Inc., Vt (g)
Morse, Fred W. Co., RI (a,b,c,g,j)
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Murray Tube Works Inc., NJ (g)
Narragansett Boiler Works, Inc., RI (g)
National Lead Construction Co., Inc., NJ (d)
National Metal Products Co., Pa (a,c,g)
National Screw & Mfg. Co., Ohio (g)
National Steel & Shipbuilding Corp., Calif (g)
National Tank Co., Okla (a,g)
Nigg Engineering Corp., Calif (a,c,g)
Olean Electro Plating Co., NY (g)
Pabst Engineering Equipment Co., Inc., NJ (a,c,f,g)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Patterson Foundry & Machine Co., Ohio (a,g)
Pennsylvania Engineering Corp., Pa (g)
Penrod, Floyd & Sons Tool & Engineering Corp., Ind (g)
Pfaudler Co., NY (a,f,g)
Phoenix Iron & Steel Co., Pa (g)
Portland Co., Me (a,f,g)
Posey Iron Works, Inc., Pa (g)
Pressed Steel Tank Co., Wis (a,f,g)
Progressive Service Co., Mo (g)
Pusey & Jones Corp., Del (a,b,c,e,f,g)
Queen Products Co., Inc., Ky (a,g)
Rankin Forge Co., Pa (c,g)
Republic Steel Corp., Ohio
(g)
Reynolds Metals Co., Va (a)
Rockwell-Standard Corp., Bossert Stamping Div., NY
(a,b,c,f,g,h,j)
Rolock, Inc., Conn (f,g)
Rose Iron Works, Ohio (a,b,c,f,g,h)
Sandy Hill Iron & Brass Works, NY (b,g)
Scaife Co., Pa (a,b,c,f,g)
Seattle Boiler Works, Inc., Wash (a,f,g)
Shank Metal Products Co., NY (a,g)
Sherman & Reilly, Inc., Tenn (a,e,f,g)
Shriver, T. & Co., Inc., NJ (a,g)
Sinclair Co., Mass (b,c,g)
Sioux City Foundry & Boiler Co., Iowa (g)
Smith, A.O. Corp., Wis (a,g)
South River Metal Products Co., Inc., NJ (a,e,g)
Southern Car & Mfg. Co., Inc., Ala (a,g)
Southwestern Porcelain Steel Corp., Okla (g)
Spincraft, Inc., Wis (a,f,g)
Spring City Foundry Co., Pa (c)
Spuck Iron & Foundry Co., Mo (g)
Stacey Mfg. Co., Ohio (a,g)
Stainless Metals, Inc., NY (c,f,h)
Standard Steel Sections, Inc., NY (a,c,g)
Stanwood Corp., Ill (g)
Star Heel Plate Co., Inc., NJ (g)
Steel, R. & Sons, Inc., NY (g)
Steel Fabricators Co., Ohio (a,c,e,f,g,h)
Stover Steel Tank & Mfg. Co., Ill (d,f,g)
Struthers Wells Corp., NY (a,f,g,h)
Sylvania Electric Products, Inc., Parts Div., Pa
(b,c,f,g)—Ad p 417
Texas Foundries, Inc., Tex (g)
Thompson Pipe & Steel Co., Colo (a,b,c,d,e,g,h)
Thys Co., Calif (g)
Toledo Stamping & Mfg. Co., Ohio (g)
Torngren, C.W. Co., Inc., Mass (a,b,c,f,g,h)
Trane Co., Wis (g)
Trojan Steel Co., W.Va (g)
Union Iron Works, Wash (g)
Union Tank Car Co., Ill (a,f,g)
United Shoe Machinery Corp., Mass (a,b,c,e,f,g)
U.S. Valve & Mfg. Co., Calif (g)
Variety Stamping Corp., Ohio (c,g)
Victor Steel Products Corp., NY (g)
Vulcan Mfg., Ohio (a,b,c,e,f,g,h)
Wal-Mar Corp., Ill (a,c,e,g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Warren Brothers Roads Co., Mass (a,c,d,e,f,g,j)
Waterman Industries, Inc., Calif (a,g)
Werner, R.D. Co., Inc., NY
West Point Foundry & Machine Co., Ga (c)
Western Foundry & Machine Works, Inc., Kan (g)
Whyte, Oliver Co., Inc., NY (a,c,g)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (a,b,c,f,g)
Wilder Mfg. Co., Inc., Calif (c,g)
Willamette Iron and Steel Co., Ore (f,g)
Wisconsin Centrifugal Foundry, Inc., Wis (b)
Woolf Aircraft Products, Inc., Mich (a,c,g)
Wyatt Metal & Boiler Works, Inc., Tex (a,b,c,e,f,g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Welding & Engineering Co., Ohio (a,f,h)

Wire

Abalon Precision Mfg. Corp., NY (a,b,c,g)
Ace Wire Spring & Form Co., Inc., Pa (g)
Acme Stamping & Mfg. Co., Pa (a,b,g)
Acme Steel Products Div., Acme Steel Co., Ill (g)
Alabama Wire Co., Inc., Ala (a)
Allegheny Ludlum Steel Corp., Pa
(g)
All-State Welding Alloys Co., Inc., NY (a,b,e,f,g,j)
Almco Steel Products Corp., Ind (g)
Alofs Mfg. Co., Mich (a,g)
Alpha Wire Corp., NY (b)
Aluminum Co. of America, Pa (a)
American Chain & Cable Co., Pa (g)
American Electric Cable Co., Mass (b,c,g)
American Nickel Alloy Mfg. Corp., NY (f)
American Reed Co., Inc., Mass (c)
American Silver Co., NY (b,f,g,h)
American Smelting & Refining Co., NY
American Steel and Wire, Div., U. S. Steel Corp., Ohio
(b,g)
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (g)
Arcos Corp., Pa (a,e,f,h)
Armco Steel Corp., Ohio (g)
Associated Spring Corp., Wallace Barnes Steel Div. Conn (g)
Athenia Steel Div., National-Standard Co., NJ (g)
Atlantic Bag Co., NY (g)
Atlantic Steel Co., Ga (g)
Baker Platinum Div., Engelhard Industries, Inc., NJ
(a,b,f,g,h)—Ad p 35
Belmont Smelting & Refining Works, Inc., NY
(d,j)
Beryllium Corp., Pa
(b)
Bethlehem Steel Co., Pa (g)
Bishop, J. & Co. Platinum Works, Pa
(f)
Bridgeport Brass Co., Conn
(a,b,f)
Bristol Brass Corp., Conn (b)
Cambridge Wire Cloth Co., Md (a,b,c,e,f,g,h)
Carol Cable Co., Div. of Crescent Co., Inc., RI (b)
Carpenter Steel Co., Pa (g)
Carpenter Steel Co., Webb Wire Div., NJ (g)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (a,b)
Cincinnati Pump & Mfg. Co., Inc., Ohio (g)
Clendenin Bros., Inc., Md (a,b)
Colonial Alloys Co., Pa (a)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (g)
Colorado Fuel and Iron Corp., Colo (g)
Colorado Fuel & Iron Corp., Pacific Coast Div., Calif (g)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (b,g)
Comerford Mfg. Co., Inc., Conn (a,b,c,e,f,g,h,j)
Continental Steel Corp., Ind (g)
Copper and Brass Sales, Inc., Mich (a,b,e)
Crown Metal Co., Wis (d)
Crucible Steel Co. of America, Pa
(f,g,h)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (h)
Curtiss-Wright Corp., Metals Processing Div., NY (g)
Dare Products, Inc., Mich (b,g)
Detroit Steel Corp., Portsmouth Div., Mich (g)
Division Lead Co., Ill (d)
Dow Chemical Co., Magnesium Div., Mich (e)
Driver, Wilbur B. Co., NJ
(b,f)—Ad p 153
Driver-Harris Co., N.J
(f)—Ad p 160
Dudek & Bock Spring Mfg. Co., Ill (a,b,g)
Eaton Mfg. Co., Reliance Div., Ohio (a,b,e,g)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Electric Auto-Lite Co., Ohio (a,b)
Electric Steel Foundry Co., Ore (g)
Electronic Parts Mfg. Co., NJ (b,f)
Elgin National Watch Co., Ill (f)
Empire Metal Co., NY (d)
Erskine Precision Wire Corp., Pa (b,f,g)
Essex Wire Corp., Magnet Wire Div., Ind (b)
Frasse, Peter A. & Co., Inc., NY
(a,g)—Ad p 92
Froman Orban Co., Inc., NY (a)
General Alloys Co., Mass (a,b,f,g)
General Cable Corp., NY (a,b)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
Greene, G.G. Corp., Pa (g)
Hawkridge Bros. Co., Mass (a,h)
Hayden Wire Works, Inc., Mass (a,b,c,d,f,g,j)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f)
Hazledine, E.T. Co., Ind (g)
Hi-Grade Alloy Corp., Ill (d)
Hoskins Mfg. Co., Mich (f)
Hudson Wire Co., NY (b)
Indiana Steel & Wire Co., Inc., Ind (g)
Indium Corp. of America, NY
(d)
International Nickel Co., Inc., NY (f)
Jarco Metal Products, NY (g)
Jelliff, C.O. Mfg. Corp., Conn (f)
Johnson Steel and Wire Co., Inc., Mass (g)
Jones & Laughlin Steel Corp., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kanthal Corp., Conn (c,f)
Keystone Steel & Wire Co., Ill (g)
Laclede Steel Co., Mo (g)
Langsenkamp, F.H. Co., Ind (b)
La Salle Steel Co., Mo (g)
Leach & Garner Co., Mass (b,f)
Lincoln Steel Corp., Neb (g)
Little Falls Alloys, Inc., NJ (a,b,h)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,e,g)
Mallory-Sharon Metals Corp., Ohio
(h)
Manganese Steel Forge Co., Pa (g)
Matthiessen & Hegeler Zinc Co., Ill (j)
Melco Wire Products, Calif (a)
Metal Goods Corp., Mo (a,b,f)
Metallizing Co. of Los Angeles, Inc., Calif (a,b,c,d,f,g,j)
Mid-States Steel & Wire Co., Ind (g)
Mid-West Wire Products Co., Inc., Mich (g)
National Electric Products Corp., Pa (a)
National Lead Co., NY (d,h)
National Lock Washer Co., NJ (g)
National Standard Div., National-Standard Co., Mich (g)
National-Standard Co., Mich
(b,c,f,g,h,j)—Ad p 375
Nesor Alloy Products Co., NJ (a,b,c,d,f,g,j)
New England Electrical Works, Inc., NH (b)
Nichols Wire & Aluminum Co., Iowa (a)
Northwestern Steel & Wire Co., Ill (g)
Okonite Co., Sub. of Kennecott Copper Corp., NJ (b)
Olin Mathieson Chemical Corp., Aluminum Div., NY
(a)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (g)
Peerless Wire Goods Co., Inc., Ind (g)
Philadelphia Steel & Wire Corp., Pa (g)
Pittsburgh Steel Co., Pa (g)
Republic Steel Corp., Ohio
(g)
Reynolds Aluminum Supply Co., Ga (a)
Reynolds Metals Co., Va (a)
Riverside-Alloy Metal Div., H. K. Porter Co., Inc., NJ
(b,f,g)
Roebling's, John A. Sons Corp. NJ (a,b,g)
Rolled Alloys, Inc., Mich (f)
Rolock, Inc., Conn (f)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Sandvik Steel, Inc., NJ
(g)

Letters in ( ) indicate materials and forms—see key previous page

Scovill Mfg. Co., Mill Products Div., Conn (b)
Seneca Wire & Mfg. Co., Ohio (g)
Sharpsville Steel Fabricators, Inc., Pa (g)
Sherman & Reilly, Inc., Tenn (g)
Simonsen Metal Products Co., Ill (a)
South River Metal Products Co., Inc., NJ (a)
Southern Metal Products Co., La (g)
Standard Metals Corp., Mass (b,f)
Star Heel Plate Co., Inc., NJ (a,b,g)
Stulz-Sickles Co., NJ (g)
Superior Mfg. Co., Pa (g)
Surprenant Mfg. Co., Mass (b)
Sylvania Electric Products, Inc., Parts Div., Pa (b,c,f,g)
Techalloy Co., Inc., Pa (f,g,h)
Tennessee Coal and Iron Div., U. S. Steel Corp., Ala (b,g)
Titan Metal Mfg. Co., Pa (b)—Ad p 388
Triangle Conduit & Cable Co., Inc., NJ (a,b)
United Wire & Supply Corp., RI (a,b)
Uniworld Research Corp. of America, Ohio (c)
Utility Mfg. Co., Mass (a,b,g)
Vanadium-Alloys Steel Co., Pa (g)
Wal-Mar Corp., Ill (a,b,c,e,g)
Washburn Wire Corp., Phillipsdale Div., RI (g)
Washington Mfg. Co., Inc., Iowa (g)
Wesco Spring Co., Ill (g)
White Metal Rolling & Stamping Corp., NY (a,e)
Whitehead Metal Products Co., Inc., NY (a,b,f,g)
Whyte, Oliver Co., Inc., NY (a,g)
Wickwire Brothers, Inc., NY (g)
Wilson Steel & Wire Co., Ill (g)
Worcester Wire Works Div., National-Standard Co., Mass (g,h)
Youngstown Sheet and Tube Co., Ohio (g)

Wire Cloth

(incl. parts)

Alabama Wire Co., Inc., Ala (a)
American Brass Co., Sub. of Anaconda Co., NY (b)
Arcos Corp., Pa (e,h)
American Steel and Wire Div., U. S. Steel Corp., Ohio (g)
Biersach & Niedermeyer Co., Wis (a,g)
Bishop, J & Co. Platinum Works, Pa (g)
Buffalo Wire Works Co., Inc., NY (a,b,c,f,g)
Cambridge Wire Cloth Co., Md (a,b,c,d,f,g,h,j)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (a,b,f)
Cleveland Wire Cloth & Mfg. Co., Ohio (a,b,c,f,g,h,j)
Cole-Roscoe Mfg. Co., Conn (b,f)
Colorado Fuel & Iron Corp., Pacific Coast Div., Calif (g)
Columbia-Geneva Steel Div., U.S. Steel Corp., Calif (g)
Electric Steel Foundry Co., Ore (g)
General Alloys Co., Mass (f)
General Cable Corp., NY (a,b)
Gilbert & Bennett Mfg. Co., Conn (a,g)
Green Bay Foundry & Machine Works, Wis (b,f)
Hewitt-Robins Inc., Conn (g)
Jelliff, C.O. Mfg. Corp., Conn (a,b,c,f,g)
Johnston & Funk Titanium Corp., Ohio (g,h)
Kenmore Machine Products, Inc., NY (f)
Manganese Steel Forge Co., Pa (a,b,c,f)
Metal Goods Corp., Mo (g)
Michigan Wire Cloth Co., Mich (a,b,f,g)
Mid-States Steel & Wire Co., Ind (g)
National-Standard Co., Mich (a,b,c,f,g,h,j)—Ad p 375
Newark Wire Cloth Co., NJ (a,b,c,f,g,h)
Pequot Wire Cloth Co., Div. of Hudson Wire Co., Conn (a,b,f,g)
Phoenix Mfg. Co., Ill (g)
Reynolds Wire Div., National-Standard Co., Ill (a,b,c,d,f,g,h,j)
Rolock, Inc., Conn (a,b,f,g)
Rotometals, Calif (a,f)
Seymour Mfg. Co., Conn (b)
Sherman & Reilly, Inc., Tenn (g)
Sinclair Co., Mass (b,g)
Star Heel Plate Co., Inc., NJ (g)
Star Wire Screen & Iron Works, Inc., Calif (a,b,c,f,g)
Taylor-Wharton Co., Div. of Harsco Corp., NJ (g)
Tennessee Coal and Iron Div., U. S. Steel Corp., Ala (g)
Tyler, W.S. Co., Ohio (a,b,c,f,g)
Uniworld Research Corp. of America, Ohio (c)
Wesbar Stamping Corp., Wis (c,g)
Whitehead Metal Products Co., Inc., NY (a,b,f)
Wickwire Bros., Inc., NY (a,b,g)
Wright, G.F. Steel & Wire Co., Mass (a,b,f,g)

Wire Forms and Parts

(except cloth)

Abalon Precision Mfg. Corp., NY (a,b,c,g)
Ace Wire Spring & Form Co., Inc., Pa (g)
Acme Stamping & Mfg. Co., Pa. (a,b,g)
All-Form Metal Products Co., Ohio (a,b,c,f,g)
Alox Mfg. Co., Mo (a,b,c,f,g)
Aluminum Co. of America, Pa (a)
American Mfg. Co., Tenn (a,g)
American Reed Co., Inc., Mass (c)
Anthes Force Oiler Co., Iowa (g)
Armco Steel Corp., Ohio (g)
Art Wire & Stamping Co., NJ (a,b,c,e,f,g,h,j)—Ad p 392
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Automotive Rubber Co., Inc., Mich (f,g)
Bethlehem Steel Co., Pa (g)
Blacher Bros., Inc., RI (b,g)
Blaco Mfg. Co., Ohio (g)
Buffalo Wire Works Co., NY (a,b,f,g)
Cambridge Wire Cloth Co., Md (a,b,f,g)
Carpenter Steel Co., Pa (g)
Cartwright, R. Tube Products Co., Mich (b)
Cincinnati Pump & Mfg. Co., Inc., Ohio (g)
Clendenin Bros. Inc., Md (a,b,g)
Cleveland Metal Products Co., Ohio (a,b,f,g)
Colorado Fuel and Iron Corp., Colo (g)
Colorado Fuel & Iron Corp., Pacific Coast Div., Calif (g)
Columbus Dental Mfg. Co., Ohio (g)
Comerford Mfg. Co., Inc., Conn (a,b,c,e,f,g)
Dare Products, Inc., Mich (g)
Dudek & Bock Spring Mfg Co., Ill (a,b,g)
Eastern Tool & Mfg. Co., NJ (a,b,g)
Electronic Parts Mfg. Co., Inc., NJ (b,f)
Elgin National Watch Co., Ill (f)
Empire Spring Co., Ohio (g)
Farwell Metal Fabricating, Minn (a,b,c,e,f,g)
Figley Die & Stamping Co., Ohio (g)
General Alloys Co., Mass (a,b,f,g)
General Cable Corp., NY (a)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
Grammes, L.F. & Sons, Inc., Pa (a,b,g)
Greene, G.G. Corp., Pa (g)
Hayden Wire Works, Inc., Mass (g)
Hodges, William & Co., Inc., Pa (g)
Hunter Spring Co., Pa (g)
Industrial Precision Products, Ill (a,b,c,e,f,g,h,j)
Irvington Form & Tank Corp., NY (g)
Judd Industries, Inc., Ohio (a,g)
King Laboratories, Inc., NY (a,f,g)
Laclede Steel Co., Mo (g)
Larkin Specialty Mfg. Co., Calif (a,b,f,g)
Leach & Garner Co., Industrial Div., Mass (a,b,f)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,e,g)
Melco Wire Products, Calif (a)
Metal Textile Corp., NJ (a,b,c,f,g,h,k)
Mid-West Wire Products Co., Inc., Mich (g)
Morse, Fred W. Co., RI (a,b,g)
Newark Wire Cloth Co., NJ (a,b,f,g,h)
Northwestern Steel & Wire Co., Ill (g)
Ormond Mfg. Co., Inc., NJ (a,b,c,f,g,h)
Parker Metal Goods Co., Mass (a,b,c,g)
Penrod, Floyd & Sons Tool & Engineering Corp., Ind (g)
Pittsburgh Steel Co., Pa (g)
Reliable Spring & Wire Forms Co., Ohio (a,b,e,f)
Republic Steel Corp., Ohio (g)
Reynolds Wire Div., National-Standard Co., Ill (a,b,e,f)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (b,f,g)
Robertson Steel & Iron Co., Ohio (a,b,g)
Rockford Bolt & Steel Co., Ill (g)
Roebling's, John A. Sons Corp., NJ (g)
Rolock Inc., Conn (a,b,f,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b,c,f,g)
Servwell Products Co., Ohio (f)
Simonsen Metal Products Co., Ill (a)
Star Heel Plate Co., Inc., NJ (g)
Steel Heddle Mfg. Co., Pa (a,b,c,e,f,g)
Superior Mfg. Co., Pa (a,c,g,j)
Sylvania Electric Products, Inc., Parts Div., Pa (a,b,c,d,f,g)
Titchener, E.H. & Co., NY (a)
Turner & Seymour Mfg. Co., Conn (a,b,g)
United Wire & Supply Corp., RI (a,b)
U.S. Steel Supply Div., U.S. Steel Corp., Ill (g)
Wal-Mar Corp., Ill (a,b,c,g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Washington Mfg. Co., Iowa (g)
Waterbury Buckle Co., Conn (a,b,g)
Wesco Spring Co., Ill (g)
Whyte, Oliver Co., Inc., Mass (g)
Wilder Mfg. Co., Inc., Calif (a,b,g)
Wire and Iron Products, Inc., Mich (a,b,c,f,g)
Wood, John Co., Minn (g)
Worth Co., Wis (a,b,e,g)

Wood—Balsa

Balsa Equador Lumber Corp., NY
Bogert & Hopper, Inc., NY
Emery, George D. Co., NY
Foss Mfg. Co., Plastics Div., Id
General Veneer Mfg. Co., Calif
International Balsa Corp., NJ
Monteath, J.H. Co., NY
Pollack, Robert Co., Calif
Sterling Models, Pa
Technical Ply-Woods Sales, Ill
Testor Chemical Co., Ill

Wood—Composition Board

Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Artyle Industries, Inc., Ohio
Balsa Equador Lumber Corp., NY
Gamble Brothers, Inc., Special Products Div., Ky
Georgia-Pacific Corp., Ore
Hardboard Div., Evans Products Co., Ore
Long-Bell Div., International Paper Co., Wash
Masonite Corp., Ill
National Starch Products, Inc., Structural Products Div., NY
Reynolds Aluminum Supply Co., Ga
Roddis Plywood Corp., Wis
Simpson Timber Co., Wash
Technical Ply-Woods Sales, Ill
U. S. Gypsum Co., Ill
Wal-Mar Corp., Ill
West Virginia Pulp & Paper Co., NY
Weyerhaeuser Timber Co., Silvatek Products Div., Wash

Wood—Impregnated and/or Compressed

Everlite Corp., Wash
Fibron Products, Inc., NY
Formica Corp., Sub. of American Cyanamid Co., Ohio
Gamble Brothers, Inc., Special Products Div., Ky
Georgia-Pacific Corp., Ore
Hardboard Div., Evans Products Co., Ore
Micarta Div., Westinghouse Electric Corp., SC
Parkwood Laminates, Inc., Mass
Reynolds Aluminum Supply Co., Ga
Simpson Timber Co., Wash
Technical Ply-Woods Sales, Ill
West Virginia Pulp & Paper Co., NY
Wood Conversion Co., Minn

Wood—Lignum Vitae

Lignum-Vitae Products Corp., NJ

Wood—Plywood

American Plywood Div., Curtis Cos., Inc., Wis
Artyle Industries, Inc., Ohio
Balsa Equador Lumber Corp., NY
Darlington Veneer Co., SC
Delta Plywood Corp., Ark
Gamble Brothers, Inc., Ky
Georgia-Pacific Corp., Ore
Long-Bell Div., International Paper Co., Wash
Nu-Ply Corp., Minn
Pilgrim Plywood Corp., Vt
Puget Sound Plywood, Inc., Wash
Reynolds Aluminum Supply Co., Ga
Roddis Plywood Corp., Wis

Simpson Timber Co., Wash
Technical Ply-Woods Sales, Ill
Timber Products Co., Ore
U. S. Plywood Corp., NY
West Virginia Pulp & Paper Co., NY

Wool Felts

(see Felts)

Wrought Iron

(see Iron)

Zinc and Its Alloys

A & A Die Casting Co., Calif (q)
Advance Stamping Co., Mich (dd)
Allied Research Products, Inc., Md
(n)—Ad p 327
Alpha Metals, Inc., NJ (v)
American Metal Climax, Inc., NY (o,w)
American Nickel Alloy Mfg. Corp., NY (q,w)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,v,w)
American Zinc Sales Co., Mo (n,o,q,w,z)
Anchor Metal Co., Inc., NY (w)
Apex Smelting Co., Ill (w)
Belmont Smelting & Refining Works, Inc., NY
(n,o,v,w,z,aa,bb,cc,dd,ff)—Ad p 159
Bunker Hill Co., Calif (n,o,z,cc,dd)
Cerro de Pasco Sales Corp., NY
(w)
Chicago Smelting & Refining Corp., Ill (w)
Clark Perforating Co., Mich (cc)
Dahlin, C.A. Co., Ill (cc,ee)
Dixon Sintaloy, Inc., Conn (o)
Duane Specialties, Ltd., NJ (w)
Eagle-Picher Co., Ohio (q,aa)
Empire Metal Co., NY (n,o,q,v,w,z,bb,cc,dd,ff)
Federated Metals Div., American Smelting & Refining Co., NY (n,w)
Fox Products Co., Pa (n)
General Smelting Co., Pa (n,w,aa)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hi-Grade Alloy Corp., Ill (n,o)
Hodgson Foundry Co., Ill (n)
Hull, R.O. & Co., Inc., Ohio (n)
Illinois Smelting & Refining Co., Ill (o,w,z,aa,bb,cc,dd)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (w,z,bb,cc,dd)
International Minerals and Metals Corp., NY (w)
Jordan Co., Ill (w)
Kirk, Morris P. & Son, Calif (n)
Lavin, R. & Sons, Inc., Ill (n,w)
Matthiessen & Hegeler Zinc Co., Ill (n,o,q,v,w,z,aa,bb,cc,dd)
McGean Chemical Co., Ohio (n,o,aa)
Metallizing Engineering Co., Inc., NY
(ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ
(aa)—Ad p 415
Modern Plating Corp., Ill (n)
National Galvanizing Co., Pa (w)
National Lead Co., NY (n,o,q,w,z,bb,cc,dd,ee)
Nesor Alloy Products Co., NJ (ff)
New England Smelting Works, Inc., Mass (o,w)
New Jersey Metals Co., NJ (n)
New Jersey Zinc Co., NY
(n,w,z,aa,dd)—Ad pp 386-387
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Peerless Alloy Co., Colo (o,w)
Pittsburgh Smelting & Refining Co., Pa (w)
Republic Metals Co., Inc., NY (n,o,w)

Addresses of Suppliers

a

A & A Die Casting Co., 12901 S Western Ave., Gardena, Calif:
ACF Industries, Inc., 30 Church St., New York 8, N.Y.
  American Car & Foundry Div., 750 3d Ave., New York 17, N.Y.
aaRBee Plastic Co., 4505 W Jefferson Blvd., Los Angeles 16, Calif.
Abalon Precision Mfg. Corp., 540 Casanova St., New York 59, N.Y.
Abbott Ball Co., 1074 New Britain Ave., Hartford 10, Conn.
Abbott Products, Inc., 150-50 12th Ave., Whitestone 57, N.Y.
Abeo Aluminum & Brass Works, 5235 Griggs Rd., Houston 21, Tex.
Abegg & Reinhold Co., 2533 E 26th St., Los Angeles 58, Calif.
Able Tool & Engineering Co., 865 N Sangamon St., Chicago 22, Ill.
Accurate Anodizing Corp., 4100 W Lake St., Chicago 24, Ill.
Accurate Brass Corp., 88th St. & 73rd Ave., Glendale, L.I., N.Y.
Accurate Die Casting Co., 3089 E 80th St., Cleveland 4, Ohio
Accurate Metal Weather Strip Co., Inc., 725 S Fulton Ave., Mt. Vernon, N.Y.
Accurate Molding Corp., 35-20 48th Ave., Long Island City 1, N.Y.
Ace Metal Spinning, 4922 S Western Ave., Chicago 9, Ill.
Ace Plastic Co., 91-30 Van Wyck Expy., Jamaica 35, N.Y.
Ace Wire Spring & Form Co., Inc., Tunnel Way, McKees Rocks, Pa.
Acheson Colloids Co., 1635 Washington, Pt. Huron, Mich.
Ackermann Mfg. Co., 1134-40 Market St., Wheeling, W. Va.
Acme Aluminum Foundry Co., 6831 S Bell Ave., Chicago, Ill.
Acme Foundry & Machine Co., Coffeyville, Kan.
Acme Foundry & Machine Co., 400 E Erisco, Blackwell, Okla.
Acme Galvanizing Co., 1733 17th St., Oakland 7, Calif.
Acme Mfg. & Gasket Co., 738-40 N 41st St., Philadelphia 4, Pa.
Acme Metal Spinning, Inc., 98 43rd Ave., NE, Minneapolis 21, Minn.
Acme Plating Co., 1563 E 21st St., Cleveland 14, Ohio
Acme Precision Products, Inc., 215 N Findlay St., Dayton 3, Ohio
Acme Resin Corp., 1401 Circle Ave., Forest Park, Ill.
Acme Specialties, Inc., 4326 N American St., Philadelphia 40, Pa.
Acme Stamping & Mfg. Co., 201-209 Corliss St., Pittsburgh 20, Pa.
Acme Steel Co., Acme Steel Products Div., 135th St. & Perry Ave., Chicago 27, Ill.
Acme Steel & Malleable Iron Works, Buffalo 7, N.Y.
Acme Tube, Inc., 212 Colt St., Irvington 11, N.J.
Acme-Newport Steel Co., 9th & Lowell Sts., Newport, Ky.
Acorn Sheet Metal Mfg. Co., Inc., 4605 W 21st St., Chicago 50, Ill.
Acro Metal Stamping Co., 332 E Reservoir, Milwaukee 12, Wis.
Acushnet Process Co. (Ad p 250)
Belleville Ave., New Bedford, Mass.
Adamas Carbide Corp., Market St., Kenilworth, N.J.
Adams Engineering Co., Inc., 19300 Biscayne Blvd., Miami, Fla.
Adams, I. G., Metalware Co., 2947 Delmar Pl., St. Louis, Mo.
Adams Plastic Products, Finlay & Providence Sts., Cincinnati, Ohio
Adhesive Products Corp., 1660 Boone Ave., New York 60, N.Y.
Adirondack Steel Casting Co., Watervliet, N.Y.
Admiral Corp., Molded Prods. Div., P.O. Box 338, West Chicago, Ill.
Advance Aluminum Castings Corp., 2742 W 36th Place, Chicago 32, Ill.
Advance Foundry Co., 107 Seminary Ave., Dayton, Ohio
Advance Galvanizing Co., 5332 Alcoa Ave., Los Angeles 58, Calif.
Advance Pressure Castings, Inc., 20 Wythe Ave., Brooklyn 11, N.Y.
Advance Screw Products Co., Inc., 3767 S Kinnickinnic Ave., Milwaukee 7, Wis.
Advance Stamping Co., 12025 Dixie Ave., Detroit 39, Mich.
Advance Tool & Die Casting Co., 3760 N Holton St., Milwaukee 12, Wis.
Aelco Foundries, Inc., 1980 S 4th St., Milwaukee 4, Wis.
Aero Screw Co., Inc., Wilmington Rd., Burlington, Wis.
Aerolite Electronics Corp., 507 26th St., Union City, N.J.
Aerolite Extrusion Co., 4605 Lake Park, Youngstown, Ohio
Aetna Felt Co., Inc., 204 Centre St., New York 13, N.Y.
Aetna Steel Co., P.O. Box 2090, Jacksonville 3, Fla.
Affiliated Screw Products Co., 757 W Waveland Ave., Chicago 18, Ill.
Air Reduction Co., Inc., 150 E 42nd St., New York 17, N.Y.
  Air Reduction Sales Co., 150 E 42nd St., New York 17, N.Y.
  Colton Chemical Co., 1747 Chester Ave., Cleveland 14, Ohio
Aircraft Screw Machine Products Co., 3521 N Halsted St., Chicago 13, Ill.
Akron Standard Mold Co., Lecromelt Casting Div., Houston St., Barberton, Ohio
Alabama Wire Co., Inc., Terrace St., Florence, Ala.
Aladdin Products Co., 608 Main St., Westbury, N.Y.
Alan Wood Steel Co., Wood Rd., Conshohocken, Pa.
Albany Car Wheel Co., Inc., 185 Broadway, Menends, N.Y.
Albany Felt Co., Broadway, Albany 1, N.Y.
Albany Novelty Mfg. Co., 107 W Canton St., Boston 18, Mass.
Albany Products Co., Inc., 351 Connecticut Ave., South Norwalk, Conn.
Albert Lea Foundry Co., 910 Marshall Ave., Albert Lea, Minn.
Albert Pipe Supply Co., Inc., 8 Berry St., Brooklyn 11, N.Y.
  Foundation Div., 101 Varick Ave., Brooklyn 37, N.Y.
Albion Malleable Iron Co., 601 N Albion St., Albion, Mich.
Albraco Metals Corp., 649 Van Sinderen Ave., Brooklyn 7, N.Y.
Albright Son & Co., 123 N Front St., Allentown, Pa.
Alcasco Foundry, 14823 Loomis Ave., Harvey, Ill.
Alco Products, Inc., 30 Church St., New York, N.Y.
Alcylite Plastics & Chemical Corp., 23874 N Pine St., Newhall, Calif.
Aidan Rubber Co., Tioga & Salmon Sts., Philadelphia 34, Pa.

Rotometals, Calif (n,o,w,aa,bb,cc,dd,ff)
St. Joseph Lead Co., NY (w)
Sall, George Metals Co., Inc., Pa (n,w)
Security Sash & Screen Co., Mich (cc)
Stevens, Frederic B., Inc., Mich (n)
Udylite Corp., Mich (n)
U. S. Reduction Co., Ind (w)
U. S. Smelting, Refining & Mining Co. NY (w)
Wall Colmonoy Corp., Mich (aa)
White Metal Rolling & Stamping Corp., NY
(o,bb,ff)

Zirconium and Its Alloys

Allegheny Ludlum Steel Corp., Pa
(o,q,v,w,z,bb,cc,dd,ee,ff)
Alloy Tube Div., Carpenter Steel Co., NY (ee)
American Silver Co., NY (v,dd,ee,ff)
Arcos Corp., Pa (ff)
Babcock & Wilcox Co., Tubular Products Div., Pa
(ee)
Belmont Smelting & Refining Works, Inc., NY
(aa)
Bishop, J. & Co. Platinum Works, Pa
(ee)
Bridgeport Brass Co., Conn
(ee)—Ad p 152
Brooks & Perkins, Inc., Mich
Carborundum Co., NY (o,q,r,v,w,z,bb,cc,dd,ee,ff)
Carborundum Metals Co., NY (o,q,v,w,z,bb,cc,dd,ee,ff)
Chase Brass & Copper Co., Sub. of Kennecott Copper Corp., Conn (ee)
Columbia National Corp., Mass (w)
Crucible Steel Co. of America, Pa
(ee)
Damascus Tube Co., Pa
(ee)—Ad p 390
Electric Steel Foundry Co., Ore (o,q,w,bb,ee)
Firth Sterling Inc., Pa (o,q,w,bb,dd)
Foote Mineral Co., Pa (o,v,aa,bb,cc,ff)
Hamilton Watch Co., Precision Metals Div., Pa (v,bb,cc,ff)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum Sales, Inc., Calif (o,q,v,w,z,bb,cc,dd,ee,ff)
Hayden Wire Works, Inc. Mass (aa)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
King Laboratories, Inc., NY (aa)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,dd,ee,ff)
Mallory-Sharon Metals Corp., Ohio
(o,q,v,w,z,bb,cc,dd,ee,ff)
Metal Hydrides, Inc., Mass (aa)
Metallizing Co. of Los Angeles, Inc., Calif (cc,ff)
Metals & Controls Corp., Mass (v,cc,dd,ee,ff)
Michigan Seamless Tube Co., Mich (ee)
National Lead Co., NY (o,q,w,z,bb,cc,dd)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Nuclear Metals, Inc., Mass (w,bb,dd,ee,ff)
Oregon Metallurgical Corp., Ore (o,q,w)
Republic Steel Corp., Steel & Tubes Div., Ohio (ee)
Superior Steel Corp., Pa (dd)
Superior Tube Co., Pa
(ee)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Tube Reducing Corp., NJ (ee)
Wah Chang Corp., NY
(w)—Ad p 146
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
(o,q,w,z,bb,cc,dd,ee)
Zirconium Metals Corp., Sub. of National Lead Co., NY

Alexander Bros. Belting Co., Walnut St. & Princess Ave., Camden 3, N.J.
Alexander, E. P. & Son, Clifton Heights, Pa.
Allegheny Foundry Co., 915 Behan St., Pittsburgh 33, Pa.
Allegheny Ludlum Steel Corp. (Ad p 81)
Oliver Bldg., Pittsburgh 22, Pa.
Allegheny Plastics, Inc., Rt. 51 & Thorn Run Rd., Coraopolis, Pa.
Allen-Stevens Corp., 33-53 62nd St., Woodside 77, N.Y.
All-Form Metal Products Co., 13000 Athens Ave., Cleveland 7, Ohio
Allied Chemical Corp., 61 Broadway, New York 6, N.Y.
  Plastics & Coal Chemicals Div., 40 Rector St., New York 6, N.Y.
  Solvay Process Div. (Ad p 329)
  61 Broadway, New York 6, N.Y.
Allied Machine Products Co., 6174 Concord Ave., Detroit 11, Mich.
Allied Metal Products Co., 81 Prescott St., Worcester 6, Mass.
Allied Products Corp., 12677 Burt Rd., Detroit 23, Mich.
Allied Research Products, Inc. (Ad p 327)
4004 W Monument St., Baltimore 5, Md.
Allied Resinous Products, Inc., Clark & Whitney Sts., Conneaut, Ohio
Allied Steel Castings Co., 1225 W 120th St., Chicago 43, Ill.
Allied Tube Corp., Bristol & Bath Sts., Philadelphia 37, Pa.
Allis-Chalmers Mfg. Co., 501 N 3rd St., La Crosse, Wis.
Allmetal Screw Products Co., Inc., 821 Stewart Ave., Garden City, N.Y.
All-Metals Precision Casting Corp., 22 School St., Yonkers, N.Y.
Alloy Cast Steel Co., Rose Ave., Marion, Ohio
Alloy Engineering & Casting Co., 1700 W Washington St., Champaign, Ill.
Alloy Metal Powders, Inc., 238 Eagle St., Brooklyn, N.Y.
Alloy Metal Products Inc., 2333 Rockingham Rd., Davenport, Iowa
Alloy Metal Wire Co., Inc., Moore Station, Prospect Park, Pa.
Alloy Precision Castings Co., 3857 W 150th St., Cleveland 11, Ohio
Alloy Products Corp. (Ad p 408)
1045 Perkins Ave., Waukesha, Wis.
Alloy Rods Co., Lincoln Hwy. W, York, Pa.
Alloy Steel Casting Co., County Line Rd., Southampton, Pa.
Alloy Steel & Metals Co., 1848 E 55th St., Los Angeles 58, Calif.
Alloy Surfaces Co., Inc., 100 S Justison St., Wilmington 1, Del.
Alloys & Chemicals Mfg. Co., Inc., 4365 Bradley Rd., SW, Cleveland 9, Ohio
All-State Welding Alloys Co., Inc., 249 Ferris Ave., White Plains, N.Y.
Almco Steel Products Corp., Wabash Ave., Bluffton, Ind.
Almont Mfg. Co., 335 E 3rd St., Imlay City, Mich.
Alofs Mfg. Co., 345 32nd St. SW, Grand Rapids 8, Mich.
Alox Mfg. Co., 6160 Maple Ave., St. Louis 14, Mo.
Alpha Metals, Inc., 56 Water St., Jersey City, N.J.
  Alphaloy Corp. Div., 2250 S Lumber St., Chicago, Ill.
Alpha Molykote Corp., 65 Harvard Ave., Stamford, Conn.
Alpha Plastics, Inc., 78 Okner Pkwy., Livingston, N.J.
Alpha Wire Corp., 200 Varick St., New York 14, N.Y
Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.
Alsynite Co. of America, 4654 De Soto St., San Diego 9, Calif.
Alten Foundry & Machine Works, Inc., 2000 W Wheeling St., Lancaster, Ohio
Aluminium Ltd. Sales, Inc., 630 5th Ave., New York 20, N.Y.
Aluminum Alloys Corp., 6650 W Walton Ave., Detroit 10, Mich.
Aluminum Billets, Inc., 3786 Oakwood Ave., Youngstown, Ohio
Aluminum Casting & Engineering Co., 2039 S Lenox St., Milwaukee 7, Wis.
Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa.
Aluminum Extrusions, Inc., 815 Shepherd St., Charlotte, Mich.
Aluminum Finishing Corp., 1012 E 21st St., Indianapolis 2, Ind.
Aluminum Foils Co., P.O. Box 540, Jackson, Tenn.
Aluminum Goods Mfg., Manitowoc, Wis.
Aluminum Industries, Inc., 3670 Werk Rd., Cincinnati, Ohio
Aluminum & Magnesium, Inc., 1 Huron St., Sandusky, Ohio
Aluminum Permanent Mold Co., 1054 Front Ave., NW, Grand Rapids 4, Mich.
Aluminum Specialty Co., 16th & Wollmer Sts., Manitowoc, Wis.
Amalgamated Steel Corp., 7835 Broadway Ave., Cleveland 5, Ohio
Ambassador Plastics & Mfg. Corp., 308 W Erie, Chicago 10, Ill.
Ambrit Industries, Inc., 1288 Los Angeles St., Glendale 4, Calif.
Amchem Products, Inc. (Ad p 337)
Ambler, Pa.
Amco Plastic Pipe Co., 2002 Davis St., San Leandro, Calif.
Amerace Corp., American Hard Rubber Co., Supplex Co. Div., 225 North Ave., Garwood, N.J.
Amerace Corp., American Hard Rubber Co. Div. (Ad pp 240-241)
Ace Rd., Butler, N.J.
Amercoat Corp., 4809 Firestone Blvd., South Gate, Calif.
American Agile Corp., 5461 Dunham Rd., Maple Heights, Ohio
American Aluminum Casting Co., 300 Colt St., Irvington 11, N.J.
American Asbestos Textile Corp., Stanbridge St., Norristown, Pa.
American Brake Shoe Co., 530 5th Ave., New York 36, N.Y.
  American Brakeblok Div., 900 W Maple Rd., Troy, Mich.
  American Manganese Steel Div. (Ad p 419)
  389 E 14th St., Chicago Heights, Ill.
  Amforge Div., 155 N Wacker Dr., Chicago 6, Ill.
  Brake Shoe & Castings Div., 230 Park Ave., New York, N.Y.
  Electro-Alloys Div., Taylor St. & Abbe Rd., Elyria, Ohio
  Engineered Castings Div., Mountain Read Rd. & NYCRR, Rochester 11, N.Y.
  Light Metals Dept., Railroad Ave., Mahwah, N.J.

Addresses of Suppliers

National Bearing Div., 717 Grant Bldg., Pittsburgh 19, Pa.
American Can Co., Plastics Div., 100 Park Ave., New York, N.Y.
American Cast Iron Pipe Co. (Ad p 374)
2930 16th St. N, Birmingham, Ala.
American Chain & Cable Co., Inc., Reading, Pa.
Acco Steel Casting Div., Tulpehocken St., Reading, Pa.
American Chain Div., 454 E. Princess St., York, Pa.
Page Steel & Wire Div., Box 692, Monessen, Pa.
American Crucible Products Co., 1319 Oberlin Ave., Lorain, Ohio
American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N.Y.
Formica Corp. Sub., 4614 Spring Grove Ave., Cincinnati 32, Ohio
Plastics & Resins Div. (Ad pp 231-232)
30 Rockefeller Plaza, New York 20, N.Y.
American Electric Cable Co., 181 Appleton St., Holyoke, Mass.
American Electrical Products Co., P.O. Box 200, 653 Lida St., Mansfield, Ohio
American Emblem Co., Inc., P.O. Box 116, Utica 1, N.Y.
American Fabricated Products Co., 1420 E 20th St., Indianapolis 7, Ind.
American Felt Co. (Ad p 294)
Glenville, Conn.
American Forge & Mfg. Co., P.O. Box 20, McKees Rocks, Pa.
American Foundries Co., 330 2nd St., Milan, Mich.
American Foundry Co., Inc., 1100 S Fibles Ave., Indianapolis 21, Ind.
American Insulator Corp. (Ad p 382)
New Freedom, Pa.
American Latex Products Corp., 3341 W El Segundo Blvd., Hawthorne, Calif.
American Laundry Machinery Co., Rochester, N.Y.
American Lava Corp., Steatite Div., Cherokee Blvd. & Mfrs. Rd., Chattanooga 5, Tenn.
American Light Alloys, Inc., 1265 McBride Ave., Little Falls, N.J.
American Machine & Foundry Co., W 117th St., Cleveland 11, Ohio
Cleveland Welding Div., W 117th St., Cleveland 11, Ohio
American Malleable Castings Co., Marion, Ohio
American Manganese Bronze Co., Rhawn & Torresdale Aves., Philadelphia 36, Pa.
American Mannex Corp., Easton Metal Powder Co. Div., 900 Line St., Easton, Pa.
American Mfg. Co., 124 Chestnut, Chattanooga 2, Tenn.
American Metal Climax, Inc., 500 5th Ave., New York 36, N.Y.
Amco Div. (Ad pp 161-164)
61 Broadway, New York 6, N.Y.
Climax Molybdenum Div., 500 Fifth Ave., New York 36, N.Y.
American Metal Products Co., Linsdale Ave., Detroit 4, Mich.
American Metal Products, Inc., 4500 W Mitchell Ave., Cincinnati 32, Ohio
American Metaseal Corp., 607 65th St., West New York, N.J.
American Molding Co., 2002 Davis St., San Leandro, Calif.
American Molding Powder & Chemical Co., 703 Bedford Ave., Brooklyn 8, N.Y.
American Nickel Alloy Mfg. Corp., 30 Vesey St., New York 7, N.Y.
American Nickeloid Co., 2nd & West Sts., Peru, Ill.
American Pipe & Construction Co., Northwest Div., 518 N E Columbia Blvd., Portland 11, Ore.
American Plastics Corp., 342 Madison Ave., New York 17, N.Y.
American Platinum Works, Newark 5, N.J.
American Potash & Chemical Corp., 3000 W 6th St., Los Angeles 54, Calif.
American Powdered Metals, Inc., 7-9 Philip Pl., North Haven, Conn.
American Products Corp., 525 S Dearborn St., Chicago 5, Ill.
American Products Mfg. Co., Inc., 8127-33 Oleander St., New Orleans 18, La.
American Reed Co., Inc., 2 S Broadway, Lawrence, Mass.
American Rubber Products Corp., 315 Brighton St., LaPorte, Ind.
American Sanitary Mfg. Co., Box 111, Abingdon, Ill.
American Screw Co., W Main St., Willimantic, Conn.
American Screw Products Co., 5943 Martin Ave., P. O. Box 96, Detroit 10, Mich.
American Sealants Co., 103 Woodbine St., Hartford 6, Conn.
American Sheet Metal Works, Inc., 16 Jefferson St., Waterbury 20, Conn.
American Silver Co., Inc., 36-07 Prince St., Flushing 54, N.Y.
American Sinteel Corp., 1019 Saw Mill River Rd., Yonkers, N.Y.
American Smelting & Refining Co., 120 Broadway, New York 5, N.Y.
Continuous Cast Products Div. (Ad pp 167-170)
1160 State St., Barber, N.J.
Federated Metals Div., 120 Broadway, New York 5, N.Y.
American Solder & Flux Co., 19th & Willard Sts., Philadelphia 40, Pa.
American Stamping Co., 26650 Lakeland Blvd., Cleveland 32, Ohio
American Standard Co., Youngstown Kitchens Div., Ellsworth Ave., Salem, Ohio
American Steel Foundries, Prudential Plaza, Chicago 1, Ill.
American Steel Castings Div., Ave. L & Herbert, Newark, N.J.
American Steel & Pump Corp., Oklahoma Steel Castings Div., 1200 N Peoria Ave., Tulsa, Okla.
American Synthetic Rubber Corp., 500 5th Ave., New York 36, N.Y.
American Tape Co., 4058 Beaufait Ave., Detroit 7, Mich.
American Tinning & Galvanizing Co., 552 W 12th St., Erie, Pa.
American Valve & Enameling Corp., 2855 S Holt Rd., Indianapolis 41, Ind.
American Viscose Corp., 1617 Pennsylvania Blvd., Philadelphia 3, Pa.
American Welding and Mfg. Co., 100 Dietz Rd., Warren, Ohio
American Zinc Sales Co., 1522 Paul Brown Bldg., St. Louis 1, Mo.
American-Marietta Co., 101 E Ontario St., Chicago 11, Ill.
Ames, W. & Co., 417 Communipaw Ave., Jersey City 4, N.J.
Amos-Thompson Corp., Amos Molded Plastics Div., Edinburg, Ind.
Ampco Metal, Inc., 1753 S 38th St., Milwaukee 46, Wis.
Anaconda Co., 25 Broadway, New York 4, N.Y.
American Brass Co. (Ad p 377)
25 Broadway, New York 4, N.Y.
Anaconda Metal Hose Div., 698 S Main St., Waterbury 20, Conn.
Anaconda Aluminum Co., Louisville 1, Ky.
Cochran Foil Co., 25 Broadway, New York 4, N.Y.
Anchor Hocking Glass Corp., Lancaster, Ohio
Anchor Metal Co., Inc., 966 Meeker Ave., Brooklyn 22, N.Y.
Anchor Metal Spinning Co., 46 Fluhart Ave., Dayton 8, Ohio
Anchor Plastics Corp., 36-36 36th St., Long Island City 6, N.Y.
Anderson, O.L. Co., Inc., 1347 E Fort St., Detroit 7, Mich.
Anderson Assoc., Inc., 1702 Wayne St., Toledo 1, Ohio
Anderson-Bolling Mfg. Co., Grand Haven, Mich.
Anesite Co., 3575 Touhy Ave., Chicago 45, Ill.
Anthes Force Oiler Co., 20th St. & Ave. M, Fort Madison, Iowa
Anti-Corrosive Metal Products Co., Inc., Castleton-on-Hudson, N.Y.
Apex Foundry, Inc., 633 Lycaste Ave., Detroit 14, Mich.
Apex Smelting Co., 2537 W Taylor St., Chicago 12, Ill.
Apex Steel Corp., Ltd., 6920 E Slauson, Los Angeles 22, Calif.
Apollo Metal Works, 6852 S Oak Park Ave., Chicago, Ill.
Appleton Electric Co., 1701 W Wellington Ave., Chicago 13, Ill.
Applied Instruments, Inc., 25 Will Pl., Brooklyn 7, N.Y.
Approved Mfg. Co., Inc., 307990 W 8th Mile Rd., Farmington, Mich.
Arabol Mfg. Co., 110 E 42nd St., New York 17, N.Y.
Arbonite Corp., 900 N Main St., Doylestown, Pa.
Archer-Daniels-Midland Co., 700 Investors Bldg., Minneapolis, Minn.
Arcos Corp., 1500 S 60th St., Philadelphia 43, Pa.
Ardmore Products, Inc., 194 Aldene Rd., Roselle, N.J.
Argosy Products, Inc., 7504 Carnegie Ave., Cleveland 3, Ohio
Aries Laboratories, Inc., 45-33 Davis St., Long Island City 1, N.Y.
Arkansas Foundry Co., 1423 E 6th St., Box 231, Little Rock, Ark.
Armco Steel Corp., 703 Curtis St., Middletown, Ohio
Fabricating Div., Middletown, Ohio
Sheffield Div., Sheffield Sta., Kansas City 25, Mo.
Armet Alloys, Inc., 4338 Bradley Rd., Cleveland 9, Ohio
Armitage, J. L. & Co., 245 Thomas St., Newark, N.J.
Armor Galvanizing Works, Inc., 580 Market St., San Francisco 4, Calif.
Armor Metal Products Co., 3408 Beekman, Cincinnati 23, Ohio
Armour & Co., Adhesive Div., 1355 W 31st St., Chicago, Ill.
Armstrong Cork Co., West Liberty St., Lancaster, Pa.
Armstrong Products Co., P.O. Box 1-MM, Warsaw, Ind.
Arneson Foundry Co., 3303 66th St., Kenosha, Wis.
Arnold Engineering Co., P.O. Box G, Marenge, Ill.
Arrow Metal Products Corp., 3rd Ave., Haskell, N.J.
Arrow Sintered Products Co., 1900 S Kostner Ave., Chicago 23, Ill.
Arrowhead Products, 2300 Curry St., Long Beach 5, Calif.
Art Wire & Stamping Co. (Ad p 392)
227 High St., Newark 2, N.J.
Artex Felt Co., 62 W 39th St., New York 18, N.Y.
Artmor Plastics Corp., 1003 Oldtown Rd., Cumberland, Md.
Artus Corp., 201 S Dean St., Englewood, N.J.
Artyle Industries, Inc., Box 28, Eaton, Ohio
Arvin Industries, Inc., 13th St., Columbus, Ind.
Arwood Precision Castings Corp., 321 W 44th St., New York 36, N.Y.
Arzt, T. L. Foundry Co., 4020 W Schubert Ave., Chicago 39, Ill.
Asbestos Corp. of America, 31 North Ave., Garwood, N. J.
Asbestos Textile Co., Inc., 165 W Wacker Drive, Chicago 1, Ill.
Asco Sintering Corp., 7799 Telegraph Rd., Los Angeles 22, Calif.
Ashby Mfg. Co., 1601 Woodson Rd., St. Louis 11, Mo.
Asheville-Schoonmaker Mica Co., 900 Jefferson Ave., Newport News, Va.
Ashland Oil & Refining Co., Valvoline Oil Co. Div., 3rd Ave., Freedom, Pa.
Ashtabula Mfg. Co., W 30th St., Ashtabula, Ohio
Associated Engineering & Mfg. Corp., 210 Stonehouse Rd., Glen Ridge, N. J.
Associated Spring Corp., Wallace Barnes Steel Div., 18 Main St., Bristol, Conn.
Atlantic Bag Co., 435 S 5th St., Brooklyn 11, N.Y.
Atlantic Brass Works, Inc., 2600 W Addison St., Chicago 18, Ill.
Atlantic Casting Engineering Corp. (Ad p 398)
810 Bloomfield Ave., Clifton, N.J.
Atlantic Foundry Co., 182 Beaver St., Akron 4, Ohio
Atlantic India Rubber Works, Inc., 569 W Polk St., Chicago 7, Ill.
Atlantic Steel Co., P.O. Box 1714, Atlanta 1, Ga.
Atlantic Steel Castings Co., 6th & Lloyd Sts., Chester, Pa.
Atlas Brass Foundry, 1901 Santa Fe Ave., Los Angeles 21, Calif.
Atlas Drop Forge Co., 209 W Mt. Hope Ave., Lansing, Mich.
Atlas Foundry Co., 3600 W 69th St., Cleveland 2, Ohio
Atlas Foundry & Machine Co., 3012 S Wilkeson St., Tacoma, Wash.
Atlas Foundry & Mfg. Co., 3701 Collins Ave., Richmond, Calif.
Atlas Galvanizing Co., 2639 Leonis Blvd., Los Angeles 11, Calif.
Atlas Metal Parts Co., 3232 N 31st St., Milwaukee 16, Wis.
Atlas Mineral Products Co., 161 Weber St., Mertztown, Pa.
Atlas Powder Co., Chemicals Div., Wilmington 99, Del.
Atlas Steel Construction Co., 20 Vesey St., New York 7, N.Y.
Auburn Foundry, Inc., W 11th St., Auburn, Ind.
Auburn Mfg. Co. (Ad p 420)
20 Stack St., Middletown, Conn.
Auburn Plastic Engineering, 4916 S Loomis St., Chicago 9, Ill.
Auburn Plastics, Inc., 48 Canoga St., Auburn, N.Y.
Auburn Rubber Co., Inc., W 11th St., Auburn, Ind.
Auburn Spark Plug Co., Inc., Special Products Div., 89 York St., Auburn, N.Y.
Auel Industries, Herminie, Pa.
Auld, D. L. Co., 5th Ave. & 5th St., Columbus, Ohio
Aurora Metal Co., 614 W Park Ave., Aurora, Ill.
Aurora Refining Co., P.O. Box 88, Aurora, Ill.
Autel Electronics Co., Precision Machine & Welding Div., 1122 E St. George Ave., Linden, N.J.
Auto Specialties Mfg. Co., 643 Graves St., St. Joseph, Mich.
Automatic Nut Co., Lebanon, Pa.
Automotive Rubber Co., Inc., 12594 Beech Rd., Detroit, Mich.

Avce Mfg. Corp., 420 Lexington Ave., New York, N.Y.
  American Kitchens Div., 18th & Columbia, Connersville, Ind.
  New Idea Div., 420 Lexington Ave., New York, N.Y.
Avery Label Co., Decorative Products Div., 2123 E 9th St., Cleveland 15, Ohio
Aviation Developments, Inc., 210 S Victory Blvd., Burbank, Calif.
AviSun Corp., 1608 Walnut St., Philadelphia 3, Pa.
Avondale Co., 260 Happ Rd., Northfield, Ill.
Avril, G. A. Co., Este Ave. & B&O R.R., Cincinnati, Ohio

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BLC Porous Materials Co., 809 San Antonio Rd., Palo Alto, Calif.
B & T Metals Co., 425 W Town St., Columbus 16, Ohio
Babbitt Chemical Co., Inc., 38 Prospect, New Bedford, Mass.
Babcock & Wilcox Co., Tubular Products Div. (Ad p 383)
  Beaver Falls, Pa.
Babson Dow Mfg. Co., 64 Fulda St., Roxbury, Boston 19, Mass.
Backus Novelty Co., 411 Water St., Smethport, Pa.
Bacon Felt Co., 427 W Water St., Taunton, Mass.
Badger Aluminum Extrusions, 950 Georgia Ave., Brooklyn 7, N.Y.
Badger Die Casting Corp., 201 W Oklahoma Ave., Milwaukee 7, Wis.
Badger Malleable & Mfg. Co., 223 N Chicago Ave., South Milwaukee, Wis.
Baer, N.S. Co., 1-11 Montgomery St., Hillside 5, N.J.
Baker & Co., Inc., 113 Astor St., Newark 2, N.J.
Balas Collet Mfg. Co., 1557 E 27th St., Cleveland 14, Ohio
Baldwin Mfg. Co., 140 Homer St., Waterbury 20, Conn.
Baldwin-Hill Co., 500 Breunig Ave., Trenton 3, N.J.
Baldwin-Lima-Hamilton Corp., Philadelphia, Pa.
  Eddystone Div., Philadelphia, Pa.
  Standard Steel Works Div., Burnham, Pa.
Balsa Ecuador Lumber Corp., 502 5th Ave., New York, N.Y.
Bamberger, Claude P. Inc., 1 Mt. Vernon St., Ridgefield Park, N.J.
Bangor Plastics Inc., Washington St., Bangor, Mich.
Banner Iron Works, 1920 S Kingshighway, St. Louis 10, Mo.
Barber Iron Works, Inc., 301 W 61st St., P.O. Box 6318, Shreveport, La.
Barclay Mfg. Co., 1013 S Council St., Muncie, Ind
Barium Steel Corp., 25 Broad St., New York 4, N.Y.
Barnard Foundry Co., Inc., 9 Roseland St., Springfield 7, Mass.
Barnett Foundry & Machine Co., Irvington, N.J.
Bar-Ray Products, 209 25th St., Brooklyn 32, N.Y.
Barrett Varnish Co., 1532 S 50th Court, Cicero 50, Ill.
Barrows Porcelain Enamel Corp., Langdon Farm Rd. & Penn R.R., Cincinnati 17, Ohio
Bart Mfg. Corp., 227 Main St., Belleville, N.J.
Barth Smelting Corp., 99-129 Chapel St., Newark 5, N.J
Bartlett-Thompson Co., Inc., 26 Water St., Wakefield, Mass.
Barton Products Corp., P.O. Box 305, West Bend, Wis.
Bassichis Co., 2323 W 3rd St., Cleveland 12, Ohio
Bassons Industries Corp., 1432 W Farms Rd., Bronx 60, N.Y.
Batson-Cook Co., West Point Foundry & Machine Co. Div., West Point, Ga.
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N.Y.
Baxter Foundry & Machine Works, Inc., P.O. Box 1016, Boise, Id.
Bay City Electric Steel Casting Co., Trumbull St., Bay City, Mich.
Bay City Forge Co., 1802 Cranberry St., Erie, Pa.
Bay City Foundry Co., 400 Webster St., Bay City, Mich.
Bay State Refining Co., Inc., 8 Montgomery St., Chicopee Falls, Mass.
Bay State Stamping Co., 372 Chandler St., Worcester, Mass.
Bay State Tool & Machine Co., 412 Albany, Springfield 4, Mass.
Bayley Products, Inc., 19155 Glendale Ave., Detroit 5, Mich.
Beacon Metal Mfg. Co., 1127 Atlantic Ave., Brooklyn 16, N.Y.
Bead Chain Mfg. Co., 110 Mountain Grove St., Bridgeport 5, Conn.
Bean, Morris & Co., Hyde Rd., Yellow Springs, Ohio
Bearium Metals Corp., 190 Mill St., Rochester, N.Y.
Beatty Machine & Mfg. Co., 940 150th St., Hammond, Ind.
Beaver Valley Alloy Foundry Co., Atlantic Ave., Monaco, Pa.
Beck, I. & Sons, Inc., 256 Mott St., New York 12, N.Y.
Beck Products Corp., 12255 E 8th Mile Rd., Detroit 5, Mich.
Becker Bros. Carbon Co., 3450 S Laramie Ave., Cicero 50, Ill.
Becker, L. A. Foundry Co., 1201 Hwy. 66, St. Louis 15, Mo.
Beckmann, Inc., 120 Baxter St., New York 13, N.Y.
Bee Chemical Co., 12933 S Stony Island Ave., Chicago 33, Ill.
Behringer Metal Works, Inc., 108 Jabez St., Newark 5, N.J.
Belding Corticelli Industries, 1407 Broadway, New York 18, N.Y.
Belko Corp., Kingsville, Md.
Bell, David Co., Inc., 1555 Fillmore Ave., Buffalo 11, N.Y.
Bellaire Stove Co., 19th & Union Sts., Bellaire, Ohio
Belle City Malleable Iron Co., Racine Steel Castings Div., 1442 Forest St., Racine, Wis.
Belmet Products, Inc., 503 Morgan Ave., New York 22, N.Y.
Belmont Aluminum Extrusion Co., 1228 Belmont Ave., Philadelphia 4, Pa.
Belmont Smelting & Refining Works (Ad p 159)
  330 Belmont Ave., Brooklyn 7, N.Y.
Beloit Foundry Co., 445 Gardner St., South Beloit, Ill.
Beloit Iron Works, Rock River, Beloit, Wis.
Benada Aluminum Products Co., 37 James St., Girard, Ohio
Bendix Aviation Corp., Bendix Foundries Div., Teterboro, N.J.
Benjamin Electric Mfg. Co., Northwest Hwy., Des Plaines, Ill.
Bennett Mfg. Co., 41 Mechanic, Alden, N.Y.
Bergen Point Iron Works, 233 Broadway, New York 7, N.Y.
Bergfels, William & Co., 10 Orchard St., Newark 2, N.J.
Berry Bros., 211 Leib St., Detroit 7, Mich.
Beryl Ores Co., 12900 W 100 Ave., Arvada, Colo.
Beryllium Corp. (Ad p 155)
  P.O. Box 1462, Reading, Pa.
  National Precision Casting Corp. Div., P.O. Box 396, Paoli, Pa.
Bessemer Galvanizing Works, Bessemer, Ala.
Bethandale Corp., 24040 Lakeland Blvd., Cleveland 23, Ohio
Bethlehem Steel Co., 701 3rd St., Bethlehem, Pa.
Better Finishes & Coatings, Inc., 270 Doremus Ave., Newark, N.J.
Bettinger Corp., Gore St., Waltham, Mass.
Bevan Co., 400 N Arden Dr., El Monte, Calif.
Bickford, F. H., Co., 1529 S Broadway, Dayton 8, Ohio
Biddle Screw Products Co., S Main, Sheridan, Ind.
Bierman-Everett Foundry Co., 133 S 20th St., Irvington 11, N.J.
Biersach & Niedermeyer Co., 1937 N Hubbard St., Milwaukee 12, Wis.
Biggs, Carl H. Co., Inc., 2255 Barry Ave., Los Angeles 64, Calif.
Bignall Co., Main St., Medina, N.Y.
Billings & Spencer Co., 1 Laurel St., Hartford 1, Conn.
Bingham-Herbrand Corp., Herbrand Div., Lake & Stone Sts., Fremont, Ohio
Birchwood Chemical Co., 4500 W 44th St., Minneapolis 24, Minn.
Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.
Bischoff Chemical Corp., 220 Miller Rd., Hicksville, N.Y.
Bishop, J. & Co. Platinum Works (Ad p 376)
  E King St., Malvern, Pa.
Bishopric Products Co., 4413 Este Ave., Cincinnati 32, Ohio
Bisonite Co., Inc., P.O. Box 84, Kenmore Sta., Buffalo 17, N.Y.
Biwax Corp., 3445 Howard St., Skokie, Ill.
Blacher, B., 752 Broadway, New York 3, N.Y.
Blacher Bros., Inc., 299 Carpenter St., Providence 9, R.I.
Black Bear Co., Inc., 44-45 23rd St., Long Island City 1, N.Y.
Black-Clawson Co., 1700 Grand Ave., Middletown, Ohio
  Shartle Div., 2nd & Vine Sts., Hamilton, Ohio
Blaco Mfg. Co., 6541 Euclid Ave., Cleveland 8, Ohio
Blake & Johnson Co., Waterville 48, Conn.
Blakeslee Forging Co., Plant Pl., Plantsville, Conn.
Blank, Arthur & Co., Inc., 33 Causeway St., Boston 14, Mass.
Blaw-Knox Co., 300 6th Ave., Pittsburgh 23, Pa.
Blickman, S., Inc., 536 Gregory Ave., Weehawken, N.J.
Bliss, E. W. Co., Mackintosh-Hemphill Div., 901 Bingham St., Pittsburgh, Pa.
Bliss & Laughlin, Inc., 281 E 155th St., Harvey, Ill.
Blossom Mfg. Co., Inc., 292 Fifth Ave., New York 1, N.Y.
Boatwright Paint & Varnish Works, Inc., P.O. Box 306, Norcross, Ga.
Boehm Screw Products Co., 7100 W Jefferson, Detroit 17, Mich.
Bogert & Hopper, Inc., 105 W 31st St., New York, N.Y.
Bohn Aluminum & Brass Corp., 1400 Lafayette Bldg., Detroit 26, Mich.
Bond, Charles Co., 617-623 Arch St., Philadelphia 6, Pa.
Bond International, Inc., 783 S Deacon, Detroit 17, Mich.
Bone Engineering Corp., 701 W Broadway, Glendale 4, Calif.
Bonnell, William L. Co., Inc. Newman, Ga.
Bonney-Floyd Co., 611 Marion Rd., Columbus 7, Ohio
Bonnot Co., 722 Mulberry Rd., SE, Canton 2, Ohio
Booker & Wallestad, Inc., 3330 Gorham Ave., Minneapolis 26, Minn.
Boonton Molding Co., 326 Myrtle Ave., Boonton, N.J.
Booth Felt Co., Inc., 100 Water St., Brooklyn 1, N.Y.
Boots Aircraft Nut Corp., Newtown Tpke., Norwalk, Conn.
Borden Co., Chemical Div., 350 Madison Ave., New York 17, N.Y.
Borden Chemical Co., Resinite Dept., 436 E Gutierrez St., Santa Barbara, Calif.
Borg-Warner Corp., 310 S Michigan Ave., Chicago, Ill.
  Atkins Saw Div., 402 S Illinois St., Indianapolis, Ind.
  Franklin Steel Div., Franklin, Pa.
  Ingersoll Products Div., 1000 W 120th St., Chicago 43, Ill.
  Marbon Chemical Div. (Ad pp 266-267)
  7165 Chicago Ave., Gary, Ind.
Borkland Mfg. Co., 803 Quarry Rd. at 900 Wabash Rd., Marion, Ind.
Bossick Co., Howard Ave., Bridgeport, Conn.
Bostitch, Inc., Briggs Dr., East Greenwich, R.I.
Boston Felt Co., 210 South St., Boston 11, Mass.
Boston Gear Works, 14 Hayward St., Quincy 71, Mass.
Boston Metals Co., Baldt Anchor, Chain & Forge Div., 6th & Butler Sts., Chester, Pa.
Both, O.A. Corp., 100 Nickerson Rd., Ashland, Mass.
Bound Brook Oil-Less Bearing Co., Bound Brook, N.J.
Bowling Green Rubber Co., 4143 Monroe St., Toledo 13, Ohio
Boyles Galvanizing & Plating Co., P.O. Box 187, Hurst, Texas
Bradley Paint Co., 608 W Crawford Ave., Connellsville, Pa.
Bradley & Vrooman Co., 2629 S Dearborn St., Chicago 16, Ill.
Braeburn Alloy Steel Corp., Braeburn, Pa.
Brandt, Charles T. Inc., 1700 Ridgely St., Baltimore 30, Md.
Brasco Mfg. Co., Harvey, Ill.
Brewer-Titchener Corp., 111 Port Watson St., Cortland, N.Y.
Bridgeport Brass Co. (Ad p 152)
  30 Grand St., Bridgeport 2, Conn.
  Hunter-Douglas Aluminum Div., 3016 Kansas Ave., Riverside, Calif.
  National Cored Forging Div., P.O. Box 119, South Norwalk, Conn.
Bridgeport Moulded Products, Inc., 105 Meadow St., Fairfield, Conn.
Bridgeport Rolling Mills Co., Bridgeport, Conn.
Briel Industries, Inc., 2232 E Market St., New Albany, Ind.
Briggs-Shaffner Co., 500 Brookstown Ave., Winston-Salem, N.C.
Brinkerhoff Brass & Bronze Works, Inc., 57½ Dey St., New York 7, N.Y.
Bristol Brass Corp., 580 Broad St., Bristol, Conn.
Broadway Mfg. Co., P.O. Box 252, Springdale Rd., Waukesha, Wis.
Brockway Pressed Metals, Inc., 921 Clark St., Brockway, Pa.
Brom Machine & Foundry Co., 3565 6th St., Winona, Minn.
Bronze & Steel Die Casting Co., Plane, Ill.
Brooks & Perkins, Inc. (Ad p 410)
  1950 W Fort St., Detroit 16, Mich.
Brown Corp., 213 Bellevue Ave., Syracuse 1, N.Y.
Brown Rubber Co., Inc., P.O. Box 1000, Lafayette, Ind.

- Bruce Foundry & Mfg. Co., 4040 S Evans St., Tecumseh, Mich.
- Brunswick-Balke-Collender Co., Defense Products Div., 1700 Messler St., Muskegon, Mich.
- **Brush Beryllium Co. (Ad p 149)**
  4301 Perkins Ave., Cleveland 3, Ohio
  - Pennrold Div., 501 Crescent Ave., Reading, Pa.
- Buchmann Spark-Wheel Corp., 4-20 47th Ave., Long Island City 1, N.Y.
- Buckeye Brass & Mfg. Co., 6410 Hawthorne Ave., Cleveland 3, Ohio
- Buckeye Iron & Brass Works, 324 E 3rd St., Dayton 1, Ohio
- Buckeye Molding Co., 213 S 3rd St., Miamisburg, Ohio
- Budd-Stanley Co., Inc., 43-01 22nd St., Long Island City 1, N.Y.
- Buffalo Steel Corp., Tonawanda, N.Y.
- Buffalo Wire Works Co., 320 Terrace, Buffalo 2, N.Y.
- Buffalo-Eclipse Corp., Buffalo Bolt Div., 101 East Ave., North Tonawanda, N.Y.
- Bullock, W.J. Inc., P.O. Box 539, Fairfield, Ala.
- Bundy Tubing Co., 8109 E Jefferson, Detroit 14, Mich.
- Bunker Hill Co., Sales & Fabrication Div., 660 Market St., San Francisco 4, Calif.
- **Bunting Brass & Bronze Co. (Ad p 408)**
  715 Spencer, Toledo 1, Ohio
- Burgess-Norton Mfg. Co., 737 Peyton St., Geneva, Ill.
- Burkhardt Steel Co., 869 S Broadway, Denver 9, Colo.
- Burwood Products Co., Airport Dr., Traverse City, Mich.
- **Busada Mfg. Corp. (Ad p 394)**
  32-21 Downing St., Flushing, N.Y.
- Busch, J.C. Co., 17 W 54th St., New York 19, N.Y.
- Butler Engine & Foundry Co., Inc., 151 S Monroe, Butler, Pa.
- Butler Mfg. Co., 7309 E 13th St., Kansas City, Mo.
- Button Corp. of America, 49 Dickerson St., Newark 9, N.J.
- Byers, A. M., 1810 Clark Bldg., Pittsburgh 22, Pa.
- Byrd Plastics, Inc., 2953 W 12th St., Erie, Pa.

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- C. E. M. Co., 3 School St., Danielson, Conn.
- C & G Screw Machine Products Co., P.O. Box 308, Carmel, Ind.
- Cadillac Malleable Iron Co., 10th St., Cadillac, Mich.
- Cadillac Plastic & Chemical Co., 15111 2nd Ave., Detroit, Mich.
- Caldwell, W. E. Co., 2020 Brook St., Louisville 8, Ky.
- Calfibe Co., Inc., P.O. Box 832, Redlands, Calif.
- California Drop Forge Co., 1033 Alhambra Ave., Los Angeles 12, Calif.
- California Metal Enameling Co., 6904 E Slauson Ave., Los Angeles 22, Calif.
- California Perforated Screen Co., 345-347 Folsom St., San Francisco 5, Calif.
- Callahan Zinc-Lead Co., Inc., Flexaust Div., 100 Park Ave., New York 17, N.Y.
- Calorizing Co., P.O. Box 8742, Pittsburgh 21, Pa.
- Calumet & Hecla, Inc., 13 Calumet Ave., Detroit 9, Mich.
  - Calumet Div., 11 Calumet Ave., Calumet, Mich.
  - **Wolverine Tube Div. (Ad p 403)**
    1439 Central Ave., Detroit 9, Mich.
- Calumet Steel Castings Corp., 1636 Summer St., Hammond, Ind.
- Cambridge Wire Cloth Co., Cambridge, Md.
- Camcar Screw & Mfg. Co., 600 18th Ave., Rockford, Ill.
- **Cameron Iron Works, Inc., Special Products Div. (Ad p 411)**
  P.O. Box 1212, Houston 1, Tex.
- Camfield Fiberglass Plastics, Inc., N Centennial St., Zeeland, Mich.
- Camloc Fastener Corp., 22 Spring Valley Rd., Paramus, N.J.
- Campro Co., 3131 Alliance Rd., NE, Canton 1, Ohio
- Canfield, H.O. Co., Box 529, Clifton Forge, Va.
- Cannon-Muskegon Corp., 2875 Lincoln St., Muskegon, Mich.
- Canton Malleable Iron Co., 2408 13th NE, Canton, Ohio
- Capac Mfg. Corp., Capac, Mich.
- Capitol Chemical Co., 4501 W Haddon Ave., Chicago 51, Ill.
- Capitol Products Corp., Mechanicsburg, Pa.
- Carbo Tool & Die Co., 219 Howland St., Fremont, Ohio
- Carboline Co., 32 Hanley Ct., St. Louis 17, Mo.
- Carbone Corp., 400 Myrtle Ave., Boonton, N.J.
- Carborundum Co., Niagara Falls, N.Y.
  - Refractories Div., Perth Amboy, N.J.
  - Stupakoff Div., Latrobe, Pa.
- Carborundum Metals Co., P.O. Box 32, Akron, N.Y.
- Carey, Philip, Mfg. Co., 320 S Wayne Ave., Lockland, Cincinnati 15, Ohio
- Carleton Screw Products Co., 2424 Hiawatha Ave S, Minneapolis 4, Minn.
- Carlon Products Corp., 10224 Meech Ave., Cleveland 5, Ohio
- Carlson, G.O. Inc., Thorndale, Pa.
- Carolina Asbestos Co., Davidson, N.C.
- Carondelet Foundry Co., 2101 S Kingshighway, St. Louis 10, Mo.
- Carpenter Steel Co., 101 W Bern St., Reading, Pa.
  - Alloy Tube Div., Springfield Rd., Union, N.J.
  - Webb Wire Div., 17 Liberty St., New Brunswick, N.J.
- Carroll, J.B. Co., 319 N Albany Ave., Chicago 12, Ill.
- Carroll Pressed Metal, Inc., 133 Dewey St., Worcester 10, Mass.
- Cartwright, R. Tube Products Co., 609 St. Jean Ave., Detroit 14, Mich.
- Cary Chemicals, Inc., P.O. Box 1128, New Brunswick, N.J.
- Case, J. I. Co., 702 State St., Racine, Wis.
- Caspers Tin Plate Co., 4100 W 42nd Pl., Chicago 32, Ill.
- Cast Optics Corp., 123 Newman St., Hackensack, N.J.
- Castalloy Co., Inc., W Central St., Natick, Mass.
- Casting Engineers, Inc., 2323 N Bosworth, Chicago, Ill.
- Casting Service Corp. of Michigan, Mathien Ave., Bridgman, Mich.
- Castle, A. M. & Co., 3400 N Wolf Rd., Franklin Park, Ill.
- Castle Rubber Co., P.O. Box 589, Butler, Pa.
- Catalin Corp. of America, 1 Park Ave., New York 16, N.Y.
- Cedar Heights Clay Co., 50 Portsmouth Rd., Oak Hill, Ohio
- Cellcote Co., 4832 Ridge Rd., Cleveland 9, Ohio
- **Celanese Corp. of America, Celanese Plastics Co. Div. (Ad pp 219-226)**
  744 Broad St., Newark 2, N.J.
- Celluplastic Corp., 50 Ave. L, Newark 5, N.J.
- Central Fabricators, Inc., 408-18 Poplar St., Cincinnati, Ohio
- Central Felt & Fabrics Corp., 24 W 25th St., New York 10, N.Y.
- Central Screw Co., 3501 S Shields, Chicago 9, Ill.
- Central Screw Products Co., 284 Walker St., Detroit 7, Mich.
- Centrifugal Casting Co., 147 W 42nd St., New York 36, N.Y.
- Centrifugal Casting Machine Co., P.O. Box 947, Tulsa 1, Okla.
- Centr-O-Cast & Engineering Co., 45 South St. & St. Jean Ave., Detroit 14, Mich.
- Century Die Casting Co., 2629 W Fletcher St., Chicago 18, Ill.
- Ceromet, Inc., 16233 Gale Ave., Industry, Calif.
- Cerro De Pasco Corp., Lewin-Mathes Div., 1111 Chouteau Ave., St. Louis 2, Mo.
- **Cerro de Pasco Sales Corp. (Ad p 154)**
  300 Park Ave., New York 22, N.Y.
- Chace, W.M. Co., 1600 Beard Ave., Detroit 9, Mich.
- Chain Belt Co., 4701 W Greenfield Ave., Milwaukee 1, Wis.
- Chambersburg Engineering Co., Derbyshire St., Chambersburg, Pa.
- Champion Rivet Co., Harvard Ave. & E 108th St., Cleveland 5, Ohio.
- Chandler Products Corp., 1491 Chardon Rd., Cleveland 17, Ohio
- Channel Master Corp., Ellenville, N.Y.
- Chapman Machine Co., Inc., 41 Main St., Terryville, Conn.
- Chardon Metal Products Co., Mill St., Chardon, Ohio
- Chardon Rubber Co., 6th & Washington Aves., Chardon, Ohio
- Charlotte Leather Belting Co., 209 E 12th St., Charlotte 1, N.C.
- Char-Lynn Co., Diecasting Div., 2843 26th Ave. S, Minneapolis 6, Minn.
- Chattanooga Aluminum Foundry, Inc., 2000 Chestnut St., Chattanooga 8, Tenn.
- Chemetron Corp., Tube Turns Div., 224 E Broadway, Louisville 1, Ky.
- Chemical Corp., 67 Waltham Ave., Springfield 9, Mass.
- Chemical Coatings Corp., Dividend Rd., Rocky Hill, Conn.
- Chemical Coatings & Engineering Co., Inc., 221 Brooke St., Media, Pa.
- Chemical Development Corp., Endicott St., Danvers, Mass.
- Chemical Process Co., 1901 Spring St., Redwood City, Calif.
- Chemical Products Corp., King Philip Rd., Providence 14, R.I.
- Chemore Corp., 2 Broadway, New York 4, N.Y.
- Chemung Foundry Corp., Elmira, N.Y.
- Chicago Aluminum Castings, 2647 Ogden Ave., Chicago, Ill.
- Chicago Bridge & Iron Co., 332 S Michigan Ave., Chicago 4, Ill.
- Chicago Development Corp., 5810 47th Ave., Riverdale, Md.
- Chicago Extruded Metals Co., 1642 S 54th Ave., Cicero 9, Ill.
- Chicago Gasket Co,. 1271 W North Ave., Chicago 22, Ill.
- Chicago Hardware Foundry Co., 2500 Commonwealth Ave. N, Chicago, Ill.
- Chicago Malleable Castings Co., 1225 W 120th St., Chicago 43, Ill.
- **Chicago Molded Products Corp. (Ad p 380)**
  1050 N Kolmar Ave., Chicago 35, Ill.
  - Campco Div., 2736 N Normandy Ave., Chicago 35, Ill.
  - Custom Molding Div., 1020 N Kolmar Ave., Chicago 51, Ill.
- Chicago Powdered Metal Products Co., Schiller Park, Ill.
- **Chicago Rawhide Mfg. Co., (Ad p 257)**
  1301 Elston Ave., Chicago 22, Ill.
- Chicago Rivet & Machine Co., 950 S 25th Ave., Bellwood, Ill.
- Chicago Rubber Co., Inc., 651 Market St., Waukegan, Ill.
- Chicago Smelting & Refining Corp., 3701 S Kedzie Ave., Chicago 32, Ill.
- Chicago Steel Service Co., 4444 S Kildare Ave., Chicago 32, Ill.
- Chicago Thrift-Etching Corp., 1555 N Sheffield Ave., Chicago 22, Ill.
- Chicago White Metal Casting, Inc., 5239 W Grand Ave., Chicago 39, Ill.
- Chicago-Allis Mfg. Corp., 113-125 N Green St., Chicago 7, Ill.
  - Allis Rubber Div., 113-125 N Green St., Chicago 7, Ill.
- Chicopee Mills, Inc., 47 Worth St., New York 13, N.Y.
  - Lumite Div., 47 Worth St., New York 13, N.Y.
- Chippewa Plastics, Inc., 1701 1st Ave., Chippewa Falls, Wis.
- Chromalloy Corp., 450 Tarrytown Rd., White Plains, N.Y.
  - Elyria Foundry Div., Elyria, Ohio
- Chromium Corp. of America, 100 Park Ave., New York 17, N.Y.
- Chromizing Co., 1721 E 47th St., Los Angeles 58, Calif.
- Chrysler Corp., P.O. Box 1687, Detroit 31, Mich.
  - **Amplex Div. (Ad p 389)**
    P.O. Box 2718, Detroit 31, Mich.
  - Cycleweld Div., 5437 W Jefferson, Trenton, Mich.
- Ciba Co., Inc., 622 Greenwich St., New York 14, N.Y.
  - **Plastics Div. (Ad pp 228-229)**
    Kimberton, Pa.
- Cincinnati Forging Co., 5604 Booster Pike, Cincinnati, Ohio
- Cincinnati Foundry Co., 238 W Mitchell Ave., Cincinnati 32, Ohio
- Cincinnati Pump & Mfg. Co., Inc., 3182 Beekman St., Cincinnati 23, Ohio
- City Plating Works, Inc., 905 Honeyspot Rd., Stratford, Conn.
- **Clad-Rex Corp. (Ad p 335)**
  2101 S. Indiana, Chicago 16, Ill.
- Clapp, E. D. Mfg. Co., Inc., 505 Genesee St., Auburn, N.Y.
- Clark Bros. Bolt Co., Milldale, Conn.
- Clark Perforating Co., 15875 Allen Rd., Milan, Mich.
- Clarksville Foundry & Machine Works, Commerce & Spring Sts., Clarksville, Tenn.
- Clayton & Lambert Mfg. Co., 1701 Dixie Hwy., Louisville 10, Ky.
- Clayton Mark & Co., 1900 Dempster St., Evanston, Ill.
- Clendenin Bros., Inc., 4309 Erdman Ave., Baltimore 13, Md.
- Cleveland Cap Screw Co., 4444 Lee Rd., Cleveland 28, Ohio
- Cleveland City Forge Co., 1621 Euclid Ave., Cleveland 15, Ohio
- Cleveland Electro Metals Co., 2391 W 38th St., Cleveland 13, Ohio

In contacting suppliers, please mention the Materials Selector

- Cleveland Foundry & Mfg. Co., Inc., 685 6th St., NE, Cleveland, Tenn.
- Cleveland Graphite Bronze Co., 17044 St. Clair Ave., Cleveland 10, Ohio
- Cleveland Hard Facing Co., Inc., 3047 Stillson Ave., Cleveland 5, Ohio
- Cleveland Metal Products Co., Washington & Center Sts., Cleveland 13, Ohio
- Cleveland Porcelain Enameling Co., 3100 E 65th St., Cleveland 27, Ohio
- Cleveland Pressed Products Corp., 6712 Union Ave., Cleveland 5, Ohio
- Cleveland Steel Specialty Co., Inc., 3765 E 91st St., Cleveland 5, Ohio
- Cleveland Tungsten, Inc., 10200 Meech Ave., Cleveland 5, Ohio
- Cleveland Wire Cloth & Mfg. Co., 3573 E 78th St., Cleveland 5, Ohio
- Cliff Mfg. Co., 30240 Lakeland Blvd., Wickliffe, Ohio
- Clifton Conduit Corp., 3300 Eastbourne Ave., Baltimore 24, Md.
- Clinton Co., 1216 Elston Ave., Chicago 22, Ill.
- Clinton Metal Products Co., 1076 W Locust St., Wilmington, Ohio
- Clopay Corp., Clopay Sq., Cincinnati 14, Ohio
- Closures, Inc., 46 State St., Waterbury, Conn.
- Clover Industries, Inc., 572-588 Young St., Tonawanda, N.Y.
- Cly-Del Mfg. Co., Inc., Box 1367, Waterbury, Conn.
- **Coast Mfg. & Supply Co. (Ad p 293)**
  - P.O. Box 71, Livermore, Calif.
- Coated Abrasive Products, Inc., 30208 Lakeland Blvd., Wickliffe, Ohio
- Coated Coil Corp., 513 W 30th St., New York 1, N.Y.
- Coating Products, Inc., 101 W Forest Ave., Englewood, N.J.
- Cochran Foil Co., 1430 S 13th St., Louisville, Ky.
- Cochrane Foundry, Inc., Box 749, York, Pa.
- Cohan Epner Co., Inc., 142 W 14th St., New York 11, N.Y.
- Cole-Roscoe Mfg. Co., 55 Bates Ct., South Norwalk, Conn.
- Collis Co., Clinton, Iowa
- Colonial Alloys Co., Ridge Ave. & Crawford St., Philadelphia 29, Pa.
- Colonial Art Co., Inc., Crane Ave., Westfield, Mass.
- Colonial Kolonite Co., 2232 Armitage Ave., Chicago 47, Ill.
- Colonial Plastics Mfg. Co., 2685 E 79th St., Cleveland 4, Ohio
- Colorado Fuel & Iron Corp., Continental Oil Bldg., Denver 2, Colo.
  - Pacific Coast Div., 1080 19th Ave., Oakland 6, Calif.
  - Wickwire Spencer Steel Div., 575 Madison Ave., New York 22, N.Y.
- Colt's Plastics Co., Inc., P.O. Box 119, Hartford, Conn.
- Columbia Metal Stamping Co., 11900 Harvard Ave., Cleveland 5, Ohio
- Columbia Steel & Shafting Co., Summerill Tubing Co. Div., P.O. Box 1557, Pittsburgh 30, Pa.
- Columbia Tool Steel Co., Lincoln Hwy. & State St., Chicago Heights, Ill.
- Columbian Bronze Corp., 216 N Main St., Freeport, N.Y.
- Columbian Steel Tank Co., 1509 W 12th St., Kansas City 1, Mo.
- Columbiana Pump Co., Columbiana, Ohio
- Columbia-National Corp., 70 Memorial Drive, Cambridge, Mass.
- Columbus Bolt & Forging Co., 291 Marconi Blvd., Columbus 15, Ohio
- Columbus Coated Fabrics Corp., 7th & Grand Aves., Columbus 16, Ohio.
- Columbus Dental Mfg. Co., 634 Wager St., Columbus 6, Ohio
- Columbus Jack Corp., 2200 S Third St., Columbus 7, Ohio
- Columbus Production Mfg. Co., 935 W Goodale Blvd., Columbus 8, Ohio
- Combined Industries Co., P.O. Drawer 431, Catskill, N.Y.
- Combustion Engineering, Inc., 1318 N Branch St., Chicago 22, Ill.
- Comco Plastics, Inc., 97-24 Albert Rd., Ozone Park 17, N.Y.
- Comerford Mfg. Co., Inc., 81 Farmington Ave., Bristol, Conn.
- Comet Metal Products Co., Inc., 91-04 132nd St., Richmond Hill 18, N.Y
- Commercial Chemical Co., 1021 Summer St., Cincinnati 4, Ohio
- Commercial Iron Works, 2424 Porter, Los Angeles, Calif.
- Commercial Plastics Co., 2810 W North Ave., Chicago 47, Ill.
  - Associated Plastic Div., 400 E Hines St., Midland, Mich.
- Commercial Plastics & Supply Corp., 630 Broadway, New York 12, N.Y.
- Commercial Screw Products Co., 15105 Darwin Ave., Cleveland 10, Ohio
- Commercial Shearing & Stamping Co., 1775 Logan Ave., Youngstown, Ohio
- Commercial Steel Casting Co., Cheney Ave., Marion, Ohio
- Commercialores, Inc., Box 98, Clover, S.C.
- Compacted Metals Corp., 99 Greenwood Ave., Waukegan, Ill.
- Composite Forgings, Inc., 2300 W Jefferson Ave., Detroit 16, Mich.
- Compton Foundry, Compton, Calif.
- Concord Mica Corp., 26 Crescent, Penacook, N.H.
- Condamatic Co., Inc., 2700 E 9 Mile Rd., Hazel Park, Mich.
- Conforming Matrix Corp., 12th & Woodruff Sts., Toledo 2, Ohio
- Conn Perry Mfg. Co., 4341 Horatio Ave., Detroit 10, Mich.
- Conneaut Die Casting Co., 618 Sandusky St., Conneaut. Ohio
- Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.
- Connecticut Malleable Castings Co., New Haven 6, Conn.
- Connecticut Mfg. Co., 115 Benedict St., Waterbury 20, Conn.
- Connell Asbestos Mfg. Co., 117 Martense St., Brooklyn 26, N.Y.
- Conner Mfg. Co., 828 S 17th St., Louisville, Ky.
- Consolidated Electrodynamics Corp., Rochester Div., 1775 Mt. Read Blvd., Rochester 3, N.Y.
- Consolidated Foundries & Mfg. Corp., Michigan Steel Casting Co. Div., 1999 Guoin St., Detroit 7, Mich.
- Consolidated Fruit Jar Co., 62 Water St., P.O. Box 109, New Brunswick, N.J.
- Consolidated Iron-Steel Mfg. Co., Ackerman Plastic Molding Div., 986 E 200th St., Cleveland 19, Ohio.
- **Consolidated Molded Products Corp. (Ad p 399)**
  - 1940 Thomas St., Scranton, Pa.
- Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.
- Consoweld Corp., 700 Hooker St., Wisconsin Rapids, Wis.
- Continental Boiler & Sheet Iron Works, 5603 W Park Ave., St. Louis, Mo.
- Continental Can Co., 100 E 42nd St., New York 17, N.Y.
  - Conolite Div., 205 W 14th St., Wilmington, Del.
  - Shellmar-Betner Flexible Packaging Div., 100 E 42nd St., New York 17, N.Y.
- Continental Coatings Corp., 17706 Miles Ave., Cleveland, Ohio
- Continental Copper & Steel Industries, Inc., 345 Madison Ave., New York 17, N.Y.
  - Niagara Falls Smelting & Refining Div., 2200-2214 Elmwood Ave., Buffalo 23, N.Y.
- Continental Die Casting Corp., 9615 Grinnell Ave., Detroit 13, Mich.
- **Continental Felt Co. (Ad p 300)**
  - 26 W 15th St., New York 11, N.Y.
- Continental Gin Co., Birmingham, Ala.
- Continental Rubber Works, 1985 Liberty St., Erie 6, Pa.
- Continental Screw Co., 459 Mt. Pleasant St., New Bedford, Mass.
- Continental Steel Corp., 1109 S Main St., Kokomo, Ind.
- Continental Wire & Iron Works, Continental Nu-Steel Metal Products Div., 1249 S Ashland Ave., Chicago 8, Ill.
- Continental-Diamond Fibre Corp., Newark, Del.
- Continental-Emsco Co., P.O. Box 2098, Terminal Annex, Los Angeles 54, Calif.
- Contour Extrusion Co., 517 Fayette Ave., Mamaroneck, N.Y.
- Control Parts Corp., 530 Burnside Ave., Inwood 96, L.I., N.Y.
- Conversion Chemical Corp., 98 E Main St., Rockville, Conn.
- Cooley, W.J. & Co., P.O. Box 1471, 107 Hernando, Memphis, Tenn.
- Cooper Alloy Corp., Bloy St. & Ramsey Ave., Hillside 5, N.J.
- Cooper, Peter Corp., Palmer St., Gowanda, N.Y.
- Cooper-Bessemer Corp., Mt. Vernon, Ohio
- Coors Porcelain Co., 600 9th St., Golden, Colo.
- Copolymer Rubber and Chemical Corp., P.O. Box 2591, Baton Rouge 1, La.
- Copper and Brass Sales, Inc., 6555 E Davison St., Detroit 12, Mich.
- Copper Range Co., Hussey, C.G. & Co. Div., 2850 2nd Ave., Pittsburgh 19, Pa.
- Copperweld Steel Co., Warren, Ohio
  - Aristoloy Steel Div., Mahoning Ave. Ext., Warren, Ohio
  - Ohio Seamless Tube Div., Shelby, Ohio
  - Superior Steel Div., Hammond & Gregg St., Carnegie, Pa.
- **Cordo Chemical Corp. (Ad p 262)**
  - 34 Smith St., Norwalk, Conn
- **Cordo Molding Products, Inc. (Ad p 262)**
  - 230 Park Ave., New York 17, N.Y.
- Corite Products, Inc., 6553 W George St., Chicago 34, Ill.
- Cornell and Underhill, Inc., 1310 Jefferson St., Hoboken, N.J.
- **Corning Glass Works (Ad p 295)**
  - Corning, N. Y.
- Corson Industries, 1228 Belmont Ave., Philadelphia 4, Pa.
- Couch-Uthe Co., 140 S Olive St., Elyria, Ohio
- Coyne & Paddock, Inc., 40-09 21st St., Long Island City 1, N.Y.
- Craft Mfg. Co., 2301 Davis St., North Chicago, Ill.
- Craft Metal Spinning Co., 302 E Main St., Dundee, Ill.
- Craftint Mfg. Co., 1615 Collamer Ave., Cleveland 10, Ohio
- Crane Co., 836 S Michigan Ave., Chicago 5, Ill.
- Crane Packing Co., 6400 Oakton St., Morton Grove, Ill.
- Crawford & Doherty Foundry Co., 4604 SE 17th Ave., Portland, Ore.
- Crescent Co., Inc., Carol Cable Co. Div., 90 Middle St., Pawtucket, R.I.
- Crescent Plastics, Inc., 955 Diamond Ave., Evansville 7, Ind.
- Crest Chemical Industries Corp., 72 Delavan St., Brooklyn 31, N.Y.
- Crobalt, Inc., 2800 S State St., Ann Arbor, Mich.
- Croname, Inc., 6275 Howard St., Chicago 48, Ill.
- Crosby Co., 183 Pratt St., Buffalo 4, N.Y.
- Cross Engineering Co., Carbondale, Pa.
- Crown Metal Co., 121 E Washington St., Milwaukee 4, Wis.
- Crown Non-Ferrous Foundry, Inc. Concord Ave., Chester, Pa.
- **Crucible Steel Co. of America (Ad p 33)**
  - P.O. Box 2518, Pittsburgh 30, Pa.
  - Titanium and Vacuum Metal Products Div., P.O. Box 2518, Pittsburgh 30, Pa.
  - Trent Tube Co., P.O. Box 2518, Pittsburgh 30, Pa.
- Crucible Steel Casting Co., Union Ave. & Penn R.R., Lansdowne, Pa.
- Cruver Mfg. Co., 2460 W Jackson, Chicago 12, Ill.
- CrystalX Corp., W Lenni Rd., Lenni Mills, Pa.
- Cumberland Steel Co., 101 Williams St., Cumberland, Md.
- Curbell, Inc., 777 Hertel Ave., Buffalo 7, N.Y.
- Curtis Cos., Inc., American Plywood Div., New London, Wis.
- Curtis Products Co., 7 Cherry Ave., Waterbury 4, Conn.
- Curtis Screw Co., Inc., 19 Gull St., Buffalo 13, N.Y.
- Curtiss-Wright Corp., 304 Valley Blvd., Wood-Ridge, N.J.
  - Metals Processing Div., 706 Northland Ave., Buffalo 15, N.Y.
  - Plastics Div., 50 Rockefeller Plaza, New York, N.Y.
  - Utica Div., 50500 Mound Rd., Utica, Mich.
- Cuyahoga Stamping Co., 10201 Harvard Ave., Cleveland 5, Ohio
- Cyril Bath Co., 32342 Aurora Rd., Solon, Ohio

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- Dacar Chemical Products Co., 1007 McCartney St., Pittsburgh, Pa.
- Dahlin, C. A. Co., 2727 Clybourn Ave., Chicago 14, Ill.
- Dalton Foundries, Inc., Lincoln & Jefferson Sts., Warsaw, Ind.
- **Damascus Tube Co. (Ad p 390)**
  - P.O. Box 71, Greenville, Pa.
- Dana Corp., Bennett Rd. & Sylvania Ave., Toledo 1, Ohio
  - Auburn Div., Auburn, Ind.
  - Parish Pressed Steel Div., Box 1422, Reading, Pa.
- Danby Mfg. Co., Portland, Mich.
- Danielson Mfg. Co., Lee St., Danielson, Conn.
- Dapol Plastics, Inc., 53 Northboro St., Worcester 4, Mass.
- Darby Corp., 1st & Walker Sts., Kansas City 15, Kan.
- Dare Products, Inc., 860 Betterly Rd., Battle Creek, Mich.
- Darling, L. A., Midwest Foundry Co. Div., 66-76 Clark St., Coldwater, Mich.
- Darling Valve & Mfg. Co., Walnut & Marshall Sts., Williamsport, Pa.
- Darlington Veneer Co., 4th St., Darlington, S.C.
- Daubert Chemical Co., 333 N Michigan Ave., Chicago, Ill.
- Davidson Rubber Co., 50 Brighton St., Charlestown 29, Mass.
- Davis & Hemphill, 2000 Furnace Ave., Elkridge 27, Md.

Addresses of Suppliers

- Davis, Joseph Plastics Co., Kearny, N.J.
- Davis Products Corp., 601 39th St., Brooklyn 32, N.Y.
- Dawlen Corp., 1911 Fargo Rd., Jackson, Mich.
- Day Co., 810 3rd Ave., NE, Minneapolis 13, Minn.
- Day, James B. & Co., 1872 Clybourn Ave., Hollydale, Calif.
- Dayton Bronze Bearing Co., 111 Front St., Dayton 2, Ohio
- Dayton Foundry, 11803 Industrial Ave., Hollydale, Calif.
- Dayton Malleable Iron Co., P.O. Box 980, Dayton 1, Ohio
  - G. H. R. Div., 400 Detrick St., Dayton 1, Ohio
  - Ironton Malleable Div., Ironton, Ohio
  - Meta-Mold Aluminum Co., 525 E Hamilton Rd., Cedarburg, Wis.
  - Ohio Malleable Div., Box 88, Sta. A, Columbus, Ohio
  - Pratt & Letchworth Div., 189 Tonawanda St., Buffalo 7, N.Y.
- Dayton Rogers Mfg. Co., 2824 13th Ave., S, Minneapolis 7, Minn.
- Dayton Rubber Co., Dayton 1, Ohio
  - Molded Products Div., P.O. Box 209, Three Rivers, Mich.
- Dayton Steel Foundry Co., 1366 Miami Chapel Rd., Dayton 1, Ohio
- Dearborn Stamping Co., 10501 Haggerty Ave., Dearborn, Mich.
- Debevoise Co., 74 20th St., Brooklyn 32, N.Y.
- Decatur Automatic Screw Machine Products Co., P.O. Box 26, Warrensburg, Ill.
- Decatur Casting Co., 822 Dayton Ave., Decatur, Ind.
- Decrow Engineering Corp., Main St., Middleport, N.Y.
- Deerfield Mfg. Co., 4th Ave., Mason, Ohio
- Defiance Metal Products Co., 21 Seneca St., Defiance, Ohio
- Defiance Stamping Co., Perry & German Sts., Defiance, Ohio
- De Laval Steam Turbine Co., 853 Nottingham Way, Trenton 2, N.J.
- Delaware Tool Steel Corp., 34th & Market Sts., Wilmington, Del.
- Delo Screw Products Co., 38 S Franklin St., Delaware, Ohio
- Delta Plywood Corp., Cotton Plant, Ark.
- Dennis Chemical Co., 2701 Papin St., St. Louis 3, Mo.
- Denver Plastics, Inc., 15200 W Colfax Ave., Golden, Colo.
- Dependable Automatic Screw Co., 282 S Lenard St., Waterbury 20, Conn.
- Derby Castings Co., 593 N Main St., Seymour, Conn.
- Deringer Metallurgical Corp., 8131 Monticello Ave., Skokie, Ill.
- De Sanno Foundry & Machine Co., 1919 Peralta St., Oakland 7, Calif.
- Designers Metal Corp., 469 E 159th St., Harvey, Ill.
- De Soto Paint & Varnish Co., P.O. Box 186, Garland, Tex.
- Detrex Chemical Industries, Inc., Box 501, R P K Annex 32, Detroit, Mich.
- Detroit Brass & Malleable Co., 2968 7th St., Wyandotte, Mich.
- Detroit Float & Stamping Co., 625 Monroe St., Detroit, Mich.
- Detroit Gasket & Mfg. Co., Extruded Metals Div., 12640 Burt Rd., Detroit 23, Mich.
- Detroit Macoid Corp., 12340 Cloverdale, Detroit 4, Mich.
- **Detroit Stamping Co. (Ad p 382)**
  350 Midland St., Detroit 3, Mich.
- Detroit Steel Corp., Portsmouth Div., Detroit 9, Mich.
- Deuscher, H.P. Co., 7th & Hanover Sts., Hamilton, Ohio
- Devcon Corp., Danvers, Mass.
- Devoe & Raynolds Co., Inc., Jones-Dabney Co. Div., 1481 S 11th St., Louisville 8, Ky.
- Dexter, C.H. & Sons, Inc., Windsor Locks, Conn.
- Diamond Alkali Co., 300 Union Commerce Bldg., Cleveland 14, Ohio
- Diamond Mfg. Co., W 8th St., Wyoming, Pa.
- Diamonite Products Mfg. Co., Shreve, Ohio
- Die Cast Products, Inc., 621 W Rosecrans Ave., Gardena, Calif.
- Diecast Corp., 522-524 Hupp Ave., Jackson, Mich.
- Dietzel Lead Burning Co., Narrows Run Rd., Coraopolis, Pa.
- Dimco-Gray Co., 207 E 6th St., Dayton 2, Ohio
- Dip Seal Plastics, Inc., 2311 23rd Ave., Rockford, Ill.
- Dirilyte Co. of America, Inc., 1142 S Main St., Kokomo, Ind.
- Disogrin Industries, Inc., 510 S Fulton Ave., Mount Vernon, N.Y.
- Diversey Corp., Metal Industries Div., 1820 Roscoe St., Chicago 13, Ill.
- Division Lead Co., 7742 W 61st Pl., Summit, Ill.
- Dixie Aluminum Corp., 304 E 2nd Ave., Rome, Ga.
- Dixie Bronze Co., P.O. Box 1148, Birmingham 1, Ala.
- Dixie Galvanizing & Tank Co., 1901 McQuade St., Jacksonville, Fla.
- Dixie Lead Co., Sargent Rd., Box 8625, Dallas 16, Tex.
- Dixie Plastics Mfg. Co., 3017 N Galves St., New Orleans, La.
- Dixon Corp., Burnside St., Bristol, R.I.
- Dixon, Joseph Crucible Co., Wayne & Monmouth Sts., Jersey City 3, N.J.
- Dixon Sintaloy, Inc., 535 Hope St., Stamford, Conn.
- Dodge Fibers Corp., John St., Hoosick Falls, N.Y.
- Dodge Mfg. Corp., 500 S Union St., Mishawaka, Ind.
- Dodge Steel Co., 6501 State Rd., Philadelphia 35, Pa.
- Dolin Metal Products, Inc., 315 Lexington Ave., Brooklyn 16, N.Y.
- **Dollin Corp. (Ad p 416)**
  650 S 21st St., Irvington 11, N.J.
- Donegal Steel Foundry Co., 601 E Market St., Marietta, Pa.
- Donovan, F. C. Inc., 192 South St., Boston, Mass.
- Dormont Mfg. Co., 5607 Butler St., Pittsburgh 1, Pa.
- Dostal Foundry & Machine Co., Box 180, Pontiac, Mich.
- Douglas Aircraft Co., Inc., Aircomb Div., 1720 Pico Blvd., Santa Monica Calif.
- Douglas & Sturgess, 475 Bryant St., San Francisco 7, Calif.
- Dow Chemical Co., Midland, Mich.
  - Dobeckmun Co. Div., 3301 Monroe Ave., Cleveland 13, Ohio
  - Dow Metal Products Co. Div., Midland, Mich.
  - **Plastics Div. (Ad p 239)**
    Midland, Mich.
- Dow Corning Corp., P.O. Box 592, Midland, Mich.
- Downer, Hunnewell, Inc., Mono-Seal Products Div., 44 Garden St., Everett 49, Mass.
- Downington Iron Works, 161 Wallace St., Downington, Pa.
- Dravo Corp., 102 5th Ave., Pittsburgh 22, Pa.
- Drawn Metal Tube Co., 101 Elm St., Thomaston, Conn.
- Dresser Industries, Inc., Dresser Mfg. Div., 43 Fisher Ave., Bradford, Pa.
- Dresser Operations, Inc., Clark Bros. Co. Div., Lincoln Ave. & 5th St., Olean, N.Y.
- Drexel Screw Products Co., 6200 S Oakley Ave., Chicago 36, Ill.
- **Driver, Wilbur B. Co. (Ad p 153)**
  1875 McCarter Hwy., Newark 4, N.J.
  - Western Gold & Platinum Co. Sub., 525 Harbor Blvd., Belmont, Calif.
- **Driver-Harris Co. (Ad p 160)**
  201 Middlesex St., Harrison, N.J.
- Driv-Lok Sales Corp, 777 Park Ave., Sycamore, Ill.
- Duane Specialties, Ltd., 2 Johnson St., Newark 5, N.J.
- Du-Co Ceramics Co., Box 278, Saxonburg, Pa.
- Dudek & Bock Spring Mfg. Co., 4014 W Grand Ave., Chicago 51, Ill.
- Duffin Mfg. Co., 2307 Leavitt Rd., Lorain, Ohio
- Du-Lite Chemical Corp., Middletown, Conn.
- Duluth Brass Works Co., 5002 Ramsey St., Duluth 7, Minn.
- **Dumont Corp. (Ad p 410)**
  607 Irwin St., San Rafael, Calif.
- Dunnican Assoc., 352 Plymouth Rd., Union, N.J.
- Duplex Mfg. Corp., 104 Depot St., Sherman, N.Y.
- Duplican Co., Inc., 1221 Turnpike Rd., Westboro, Mass.
- **du Pont de Nemours, E. I. & Co., Inc. (Ad pp 246, 289)**
  Wilmington 98, Del.
- Dura Flex Co., 2043 Colorado Ave., Santa Monica, Calif.
- Dura Plastics of New York, Inc., 303 5th Ave., New York 16, N.Y.
- Durable Formed Products, Inc., 74 Varick St., New York 13, N.Y.
- Durable Rubber Products Co., 609 W Lake St., Chicago 6, Ill.
- Duralac Chemical Corp., 84 Lister Ave., Newark 5, N.J.
- Dura-Lee Corp., 908 Broadway, Kansas City, Mo.
- **Duraloy Co. (Ad p 401)**
  Bridge St., Scottdale, Pa.
- Durethene Corp., 1859 S 55th Ave., Chicago 50, Ill.
- Duriron Co., Inc., 450 N Findlay St., Dayton, Ohio
- Duro Screw & Mfg. Co., 1064 Springfield Rd., Union, N.J.
- Du-Wel Metal Products, Inc., P.O. Box 307, Bangor, Mich.
- **Dyna-Therm Chemical Corp. (Ad p 334)**
  3813 Hoke St., Culver City, Calif.

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- Eagle-Picher Co., American Bldg., Cincinnati 1, Ohio
  - Chicago Vitreous Corp. Div., 1425 S 55th Ct., Cicero 50, Ill.
  - **Fabricon Products Div. (Ad p 255)**
    1721 W Pleasant Ave., River Rouge 18, Mich.
- Earl Paint Corp., 240 Genesee St., Utica 2, N.Y.
- Earley, Sam C. Corp., 3230 Monroe St., Toledo 6, Ohio
- East Birmingham Bronze Foundry Co., 831 N 36th Way, Birmingham 4, Ala.
- Eastern Brass & Copper Co., 1122 E 180th St., New York 60, N.Y.
- Eastern Machine Screw Corp., Truman & Barclay Sts., New Haven 6, Conn.
- Eastern Malleable Iron Co., P.O. Box 349, Wilmington 99, Del.
- Eastern Rolling Mills, Inc., 1122 E 180th St., New York 60, N.Y.
- Eastern Smelting & Refining Corp., 109 W Brookline St., Boston 18, Mass.
- **Eastern Stainless Steel Corp. (Ad pp 90-91)**
  P.O. Box 1975, Baltimore 3, Md.
- Eastern Tool & Mfg. Co., 1 Montgomery St., Belleville 9, N.J.
- Eastern Tool & Stamping Co., Inc., 110 Ballard St., Saugus, Mich.
- Eastman Kodak Co., 343 State St., Rochester 4, N.Y.
  - Cellulose Products Sales Div., 343 State St., Rochester 4, N.Y.
  - **Eastman Chemical Products, Inc. Sub. (Ad p 456)**
    Kingsport, Tenn.
  - Texas Eastman Co. Div., Longview, Tex.
- Easton Plastic Products Co., Inc., 900 Line St., Easton, Pa.
- Eaton Mfg. Co., 9711 French Rd., Detroit, Mich.
  - Foundry Div., 700 E Huron, Vassar, Mich.
  - Powdered Metals Div., 325 Jay St., Coldwater, Mich.
  - Reliance Div., 25 Charles Ave., Massillon, Ohio
- Eberhard Faber Pencil Co., 37 Greenpoint Ave., Brooklyn, N.Y.
- Eberhart Steel Products, Powdered Metals Div., 317 E Jefferson Blvd., Mishawaka, Ind.
- Eby, Hugh H. Co., 4701 Germantown Ave., Philadelphia 20, Pa.
- Eclipse Plastic Industries, Inc., Box 430, Sarasota, Fla.
- Economy Machine Products Co., 5214 W Lawrence Ave., Chicago 30, Ill.
- Edgar Plastic Kaolin Co., Materdyne Ave., Edgar, Fla.
- Edgcomb Steel & Aluminum Corp., Hillside Ave., N.J.
- Edna Lite Optical Co., Inc., 200 N Water St., Peekskill, N.Y.
- Egan & Hausman Co., Inc., 9-02 43rd Rd., Long Island City 1, N.Y.
- Egyptian Lacquer Mfg. Co., P.O. Box 444, Newark 1, N.J.
- Ehrsam, J. B. & Sons Mfg. Co., Enterprise, Kan.
- Eimco Corp., American Foundry & Machine Div., P.O. Box 300, Salt Lake City 10, Utah
- Ekstrand & Tholand, 420 Lexington Ave., New York 17, N.Y.
- Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N.J.
- Elastomer Chemical Corp., 212 Wright St., Newark 7, N.J.
- Eichinger, Charles F., 916 Magazine St., New Orleans 12, La.
- Elco Tool and Screw Corp., 1800 Broadway, Rockford, Ill.
- Electric Auto-Lite Co., Champlain & Mulberry Sts., Toledo 1, Ohio
  - Woodstock Div., 501 Clay St., Woodstock, Ill.
- Electric Materials Co., Clay & Washington Sts., North East, Pa.
- Electric Steel Castings Co., 1045 Main St. Speedway, Indianapolis 24, Ind.
- Electric Steel Foundry Co., 2141 NW 25th Ave., Portland 10, Ore.
- Electric Storage Battery Co., Stokes Molded Products Div., Taylor St. & Webster, Trenton 4, N.J.
- Electrical Refractories Co., East Palestine, Ohio

In contacting suppliers, please mention the Materials Selector

Electro Chemical Engineering & Mfg. Co., 750 Broad St., Emmaus, Pa.
Electro Refractories & Abrasives Corp., Willett Rd., Lackawanna 18, N.Y.
Electrocast Steel Foundry Co., 4701 W 15th Place, Cicero 50, Ill.
Electrofilm, Inc., 7116 Laurel Canyon Blvd., North Hollywood, Calif.
Electrolizing Co., 1505 East End Ave., Chicago Heights, Ill.
Electron Corp., 651 Rio Grande Ave., Littleton, Colo.
Electronic Parts Mfg. Co., Inc., 508 25th St., Union City, N.J.
Elgin National Watch Co., 107 National St., Elgin, Ill.
Eljay Corp., 2900 Herbert St., Baltimore 16, Md.
Elk Engineering Works, Inc., 220 Stackpole St., St. Marys, Pa.
Elkhart Foundry & Machine Co., Inc., 220-330 S Elkhart Ave., Elkhart, Ind.
Elkhart Iron Works, 1217-33 Broad St., St. Joseph, Mich.
Elliott Bros. Steel Co., 902-914 N Cedar St., New Castle, Pa.
Ellwood City Iron & Wire Co., 416 Pittsburgh Circle, Ellwood City, Pa.
Elm Coated Fabrics Co., Inc., 261 5th Ave., New York 16, N.Y.
Elsby, J.S. Inc., 3223 W Burnham St., Milwaukee 15, Wis.
Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.
Emerson-Sack-Warner Corp., 85 Washington St., Somerville, Mass.
Emery, George D. Co., 220 11th Ave., New York, N.Y.
Emmaus Foundry & Machine Co., 4th & Furnace Sts., Emmaus, Pa.
Empire Foundry Co., Inc., 429 3rd St., Oakland 7, Calif.
Empire Metal Co., 820 E Water St., Syracuse 3, N.Y.
Empire Pattern and Foundry Co., P.O. Box 1647, Tulsa 1, Okla.
Empire Spring Co., 210 S Albe St., Elyria, Ohio
Empire Steel Castings, Inc., P.O. Box 139, Reading, Pa.
Enamel Products Co., 341 Eddy Rd., Cleveland 8, Ohio
Endicott Forging & Mfg. Co., Inc., 1901 North St., Endicott, N.Y.
Enflo Corp., Fellowship Rd. & Rt. #73, Maple Shade, N.J.
Engelhard Industries, Inc., 904 Passaic Ave., East Newark, N.J.
American Platinum & Silver Div. (Ad pp 35, 461)
231 New Jersey R.R. Ave., Newark 5, N.J.
Amersil Quartz Div. (Ad p 34)
685 Ramsey Ave., Hillside, N.J.
Baker Platinum Div. (Ad p 35)
113 Astor St., Newark. N.J.
Makepeace, D.E. Div., Pine & Durham Sts., Attleboro, Mass.
Wilson, H. A. Div. (Ad p 34)
2655 U.S. Rte. 22, Union, N.J.
Engineered Nylon Products, Inc., 1318 S Olive St., South Bend, Ind.
Engineered Plastics, Inc., American Sinterings Div., P.O. Drawer P, Watertown, Conn.
Engineered Precision Casting Co., Highway 79, P.O. Box 68, Matawan, N.J.
Engineering Products & Specialties, Inc., Dunnel Lane, Pawtucket, R.I.
Englander Co., Inc., Industrial Products Div., 227 N. Warwick Ave., Baltimore 23, Md.
Enjay Co., Inc. (Ad p 247)
15 W 51st St., New York 18, N.Y.
Enoch Mfg. Co., P.O. Box 5201, Portland 16, Ore.
Enterprise Galvanizing Co., 2507 E Cumberland St., Philadelphia 25, Pa.
Enterprise Wheel & Car Corp., P.O. Box 151, Bristol, Va.
Enthone, Inc., 442 Elm St., New Haven 8, Conn.
Erdle Perforating Co., Inc., 171 York St., Rochester 11, N.Y.
Erie Bolt & Nut Co., 1325 Liberty St., Erie, Pa.
Erie Bronze Co., 19th & Chestnut Sts., Erie, Pa.
Erie Casting Co., 1534 German St., Erie, Pa.
Erie Ceramic Arts Co. (Ad p 336)
3120 W 22nd St., Erie, Pa.
Erie Enameling Co., 1400 W 20th St., Erie 4, Pa.
Erie Malleable Iron Co., 680 W 12th St., Erie, Pa
Erie Resistor Corp., Plastics Div., 644 W 12th St., Erie, Pa.
Erie Scientific Corp., 693 Seneca St., Buffalo 10, N.Y.
Erskine Precision Wire Corp., 210 S Broad St., Emporium, Pa.
Ervite Corp., 4000 W Ridge Rd., Erie, Pa.
Escambia Chemical Corp., 261 Madison Ave., New York 16, N.Y.
Essential Bar Products Co., 2526 Brooklyn Road, Jackson, Mich.
Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.
Carolina Industrial Plastics Div., Mount Airy, N.C.
Magnet Wire Div., 1601 Wall St., Fort Wayne, Ind.
Est Co., Inc., Grafton, Wis.
Etched Products Corp., 1100 Brook Ave., New York 56, N.Y.
Ethylene Chemical Corp., 245 Broad St., Summit, N.J.
Eureka Electric Products Co., Clay St., North East, Pa.
Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing 58, N.Y.
Evans, George Corp., 121 37th St., Moline, Ill.
Evans Metal Co., 740 Lambert Dr. NE, Atlanta 5, Ga.
Evans Products Co., Hardboard Div., P.O. Box 651, Corvallis, Ore.
Everard Tap & Die Corp., 215 E 144th St., New York 51, N.Y.
Everlite Corp., 1213 E Cherry St., Seattle 22, Wash.
Exalco Mfg. Co. (Ad p 414)
46 Sheldon Rd., Berea, Ohio
Excelsior Leather Washer Mfg. Co., Inc., 720 Chestnut St., Rockford, Ill.
Exeter Mfg. Co., 1451 Broadway, New York 36, N.Y.
Extruders, Inc., 3232 W El Segundo Blvd., Hawthorne, Calif.
Eynon-Dakin Co., 9900 Freeland Ave., Detroit 27, Mich.

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Fabristeel Products, Inc., 21500 W 8 Mile Rd., Detroit 41, Mich.
Fahralloy Co., 149th St. & Loomis St., Harvey, Ill.
Fairbanks, Morse & Co., Beloit, Wis.
Fairchild Engine & Airplane Corp., Al-Fin Div., Comac Rd., Deer Park, N.Y.
Fairchild Screw Products, Inc., White St., Winsted, Conn.
Fairfield Aluminum Castings Co., 603 N 8th St., Fairfield, Iowa
Fairmont Aluminum Co., Fairmont, W. Va.
Falge Engineering Corp., 4733 Elm St., Bethesda 14, Md.
Falk Corp., 3001 W Canal St., Milwaukee 1, Wis.
Falls Machine Co., 1625 Massillon Rd., Akron 12, Ohio
Falstrom Co., 86 Falstrom Ct., Passaic, N.J.
Fanner Mfg. Co., Brookside Park, Cleveland 9, Ohio
Munray Products Div., 12400 Crossburn Ave., Cleveland 11, Ohio
Fansteel Metallurgical Corp. (Ad pp 158, 159)
2200 Sheridan Rd., North Chicago, Ill.
Farley & Loetscher Mfg. Co., Plastics Div., 7th & White, Dubuque, Iowa
Farnam Mfg. Co., 2000 Sweeten Creek Rd., Asheville, N.C.
Farrel-Birmingham Co., Inc., 25 Main St., Ansonia, Conn.
Farrelloy Co., 1243-45 N 26th St., Philadelphia 21, Pa.
Farwell Metal Fabricating, 77 W Fairfield Ave., St. Paul 7, Minn.
Faultless Rubber Co., Ashland, Ohio
Fearon Foundry Co., 1420 W Kinzie St., Chicago 22, Ill.
Federal Die Casting Co., 2226 N Elston, Chicago, Ill.
Federal Machine and Welder Co., 1745 Overland Ave. NE, Warren, Ohio
Federal Malleable Co., 805 S 72nd St., Milwaukee, Wis.
Federal Screw Works, Congdon St., Chelsea, Mich.
Federal Steel Products Corp., 415 N St. Charles St., Houston 3, Tex.
Federal Tool Corp., 3600 W Pratt Blvd., Chicago 45, Ill.
Federal Tool Mfg. Co., 3600 Alabama Ave., Minneapolis 16, Minn.
Felt Products Mfg. Co., 7450 N McCormick Blvd., Skokie, Ill.
Felters Co. (Ad p 298)
220 South St., Boston 11, Mass.
Femco Mfg. Co., Inc., 22845 Hoover Rd., Detroit 5, Mich.
Fenestra, Inc., 2250 E Grand Blvd., Detroit 11, Mich.
Ferro Corp., 4150 E 56th St., Cleveland 5, Ohio
Fiber Glass Div., Fiber Glass Rd., Nashville 11, Tenn.
Louthan Mfg. Co. Div. P.O. Box 781, East Liverpool, Ohio
Ferro Enameling Co., 1100 57th Ave., Oakland 21, Calif.
Ferro Powdered Metals, Inc., Box 312, Salem, Ind.
Ferro-Co Corp., Schori Process Div., 8-11 43rd Rd., Long Island City 1, N.Y.
Fiber Glass Industries, Inc., Amsterdam, N.Y.
Fiberfil, Inc., Fox Farm Road, Warsaw, Ind.
Fiberglass Ohio Inc., 9603 Clinton Rd., Cleveland 9, Ohio
Fiberite Corp. (Ad p 259)
516 W 4th, Winona, Minn.
Fibron Products, Inc., 500 Fibron Bldg., 45 Mechanic St., Buffalo 2, N.Y.
Fidelity Chemical Products Corp., 470 Frelinghuysen Ave., Newark 12, N.J.
Fidelity Felt & Mfg. Co., 22 W 15th St., New York 11, N.Y.
Figley Die & Stamping Co., 401 Agnes St., Defiance, Ohio
Filon Plastics Corp., 2051 E Maple Ave., El Segundo, Calif.
Filpaco Industries, Inc., 2426 S Michigan Ave., Chicago 16, Ill.
Fine Organics, Inc., 209-211 E 19th St., New York, N.Y.
Finkl, A. & Sons Co., 2011 Southport Ave., Chicago 14, Ill.
Firestone Plastics Co., P.O. Box 690, Pottstown, Pa.
Firestone Tire & Rubber Co., 1200 Firestone Pkwy., Akron 17, Ohio
World Bestos Div., 1112 S 25th St., New Castle, Ind.
Firth Sterling, Inc., 3113 Forbes St., Pittsburgh, Pa.
Fischer Casting Co., Inc., P.O. Box M, Dunellen, N.J.
Fischer Special Mfg. Co., 450 Morgan St., Cincinnati 20, Ohio
Fish-Schurman Corp., 70 Portman Rd., New Rochelle, N.Y.
Fitchburg Foundry, Inc., Benson St., Fitchburg, Mass.
Fitzgibbons Boiler Co., Inc., Oswego, N.Y
FitzSimons Mfg. Co., 3775 E Outer Drive, Detroit 34, Mich.
Fletcher Enamel Co., P.O. Box 67, Dunbar, W. Va.
Flexfirm Products, 2300 N Chico Ave., El Monte, Calif.
Flexible Tubing Corp., Guilford, Conn.
Flexonics Corp., 1315 S 3rd Ave., Maywood, Ill.
Flexrock Co., 36th & Filbert Sts., Philadelphia 1, Pa.
Fluoro-Plastics Inc. Div., 36th & Filbert Sts., Philadelphia 1, Pa.
Flood City Brass & Electric Co., Messenger & Elder Sts., Johnstown, Pa.
Florence Pipe Foundry & Machine Co., Front St., Florence, N.J.
Florin Foundry & Mfg. Co., Florin, Pa.
Flynn & Emrich Co., 301 Holliday St., Baltimore 2, Md.
Flynn, Michael Mfg. Co., 700 E Godfrey Ave., Philadelphia 24, Pa.
Foam Products, Inc., P.O. Box 27, Manchester, Pa.
Foamade Industries, 14851 W 11 Mile Rd., Oak Park 37, Mich.
Foamalum Corp., 508 Water St., Peru, Ill.
Follansbee Steel Corp., Sheet Metal Specialty Div., P.O. Box 567, Follansbee, W. Va.
Food Machinery & Chemical Corp., 161 E 42nd St., New York 17, N.Y.
Chemicals & Plastics Div., 161 E 42nd St., New York 17, N.Y.
F M C Organic Chemicals Div., 161 E 42nd St., New York 17, N.Y.
Foote Mineral Co., 18 W Chelten Ave., Philadelphia 44, Pa.
Fordsell Machine Products Co., 4433 E 8 Mile Rd., Van Dyke, Mich.
Forg, Peter Mfg. Co., Park St., Somerville 43, Mass.
Formed Tubes, Inc., Prairie & Albert Sts., Sturgis, Mich.
Fort Howard Steel & Wire Co., 200 9th St., Green Bay, Wis.
Fort Worth Steel & Machinery Co., 3504 Jackson St., Fort Worth, Tex.
Foss Mfg. Co., Plastics Div., 225 2nd Ave., Twin Falls, Id.
Foster Aluminum Alloy Products Corp., Pearl St., Forestville, N.Y.
Foster Grant Co., 289 N Main St., Leominster, Mass.
Foster Wheeler Corp., 165 Broadway, New York, N.Y.
Fox Co., 3400 Beekman St., Cincinnati, Ohio
Fox Edge Co., Inc., 1995 Middlesex St., Lowell, Mass.
Fox Products Co., 4720 N 18th St., Philadelphia 41, Pa.
France, J. H. Refractories Co., Snow Shoe, Pa.
Franklin Cotton Mill Co., 1108 Central Pkwy., Cincinnati 10, Ohio
Franklin Glue Co., 119 Chestnut St., Columbus 15, Ohio
Franklin Mineral Products Co., P.O Box 28, Franklin, N.C.
Franklin Plastics, Inc., 315 Grant St. Franklin, Pa.
Frasse, Peter A. & Co., Inc. (Ad p 92)
17 Grand St., New York 13, N.Y
Frederick Iron & Steel, Inc., 7th & East Sts., Frederick, Md.

Fremont Casting Co., 105 Fremont St., Worcester, Mass.
Frenchtown Porcelain Co., Frenchtown, N.J.
Friedrich & Dimmock, Inc., Lincoln Ave., Millville, N.J.
Frisby, R. J. Mfg. Co., 246 N Western Ave., Chicago 12, Ill.
Fromson Orban Co., Inc., 261 Madison Ave., New York, N.Y.
Frontier Bronze Corp., 4870 Packard Road, Niagara Falls, N.Y.
Frost Paint & Oil Corp., 1203 NE Tyler, Minneapolis, Minn.
Frost Rubber Co., 1407 N Dayton St., Chicago 22, Ill.
Fry Plastics Co., 7826 S Vermont Ave., Los Angeles 44, Calif.
Fryling Mfg. Co., 531 W 11th St., Erie, Pa.
Fuller, H. B. Co., 255 Eagle, St. Paul 2, Minn.
Fuller, W. P. & Co., 301 Mission St., San Francisco, Calif.
Fullerton Mfg. Co., 343 E Santa Fe Ave., Fullerton, Calif.
Fulton Foundry & Machine Co., Inc., Cleveland, Ohio
Fulton Gold Refiners Corp., 71 Fulton St., New York 38, N.Y.
Funkhouser Co., P.O. Box 569, Hagerstown, Md.
Furane Plastics, Inc., 4516 Brazil St., Los Angeles 39, Calif.

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G. & C. Foundry Co., Monroe & Olds St., Sandusky, Ohio
G & G Mfg. Co., 3223 W Fillmore St., Chicago 24, Ill.
G & Z Automatic Products Co., 2434 Brooklyn Rd., Jackson, Mich.
Gale Mfg. Co., 115 N Albion St., Albion, Mich.
Galigher Co., 545 W 8th St., P.O. Box 209, Salt Lake City 10, Utah
Gamble Bros., Inc., Special Products Div., 4601 Allmond Ave., Louisville 9, Ky.
Gantner Screw Products Co., Inc., 20 S Walnut St., Springfield, Ohio
Gar Precision Parts, Inc., 190 Henry St., Stamford, Conn.
Garco Mfg. Co., Inc., 744 N Ada St., Chicago 22, Ill.
Garden State Forge Co., 1501 Jersey St., South Plainfield, N.J.
Gardner-Denver Co., 100 Williamson St., Quincy, Ill.
Garfield Mfg. Co., 10 Midland Ave., Wallington, N.J.
Garlock Packing Co., 402 Main St., Palmyra, N.Y.
U.S. Gasket Plastics Div. (Ad p 393)
600 N 10th St., Camden 1, N.J.
Gartland Foundry Co., 4th & Grant Sts., Terre Haute, Ind.
Gartland-Haswell Foundry, Inc., 430 W Park St., Sidney, Ohio
Gary Lynn Co., 926 York St., Cincinnati 14, Ohio
Gary Steel Products Corp., P.O. Box 449, Lynchburg, Va.
Gates Engineering Co., 100 S West St., Wilmington 99, Del.
Gates Rubber Co., 999 S Broadway, Denver, Colo.
Gatke Corp., Engineering Div., 228 N LaSalle St., Chicago 1, Ill.
Geauga Industries Co., Middlefield, Ohio
General Alloys Co., 465 W 1st St., South Boston, Mass.
General Aluminum Mfg. Co., 3027 E 55th St., Cleveland 27, Ohio
General American Transportation Corp., 135 S LaSalle St., Chicago 90, Ill.
Parker-Kalon Div., 1 Peekay Dr., Clifton, N.J.
Plastics Div. (Ad p 425)
135 S LaSalle St., Chicago 90, Ill.
Plate & Welding Div., 135 S LaSalle St., Chicago 90, Ill.
General Aniline & Film Corp., Antara Chemicals Div., 435 Hudson St., New York 14, N.Y.
General Asbestos Gasket Mfg. Corp., 1721 S 7th St., St. Louis 4, Mo.
General Cable Corp., 420 Lexington Ave., New York 17, N.Y.
General Ceramics Corp., Crows Mill Rd., Keasbey, N.J.
General Drop Forge Corp., 1738 Elmwood Ave., Buffalo, N.Y.
General Dynamics Corp., Liquid Carbonic Div., 3100 S Kedzie Ave., Chicago 23, Ill.
General Electric Co., 1 River Rd., Schenectady 5, N.Y.
Chemical Materials Dept., 1 Plastics Ave., Pittsfield, Mass.
Chemical & Metallurgical Div., 2200 N 22nd St., Decatur, Ill.
Foundry Dept., 1 River Rd., (Bldg. 96), Schenectady, N.Y.
Insulating Materials Dept., 23 River Rd., Schenectady 5, N.Y.
Laminated Products Dept. (Ad p 244)
Coshocton, Ohio
Lamp Wire & Phosphors Dept., 21800 Tungsten Rd., Cleveland 17, Ohio
Metallurgical Products Dept., P.O. Box 237, Roosevelt Park Annex, Detroit 32, Mich.
Plastics Dept., N 22nd St., Decatur, Ill.
Silicone Products Dept., Waterford, N.Y.
General Engineering Works, 4701 W Division St., Chicago 51, Ill.
General Extrusions, Inc. (Ad p 416)
4040 Lake Park Rd., Youngstown 12, Ohio
General Findings & Supply Co., Industrial Div., School & Pearl Sts., Attleboro, Mass.
General Foundry & Mfg. Co., Flint, Mich.
General Gasket, Inc., Middletown, Conn.
General Industries Co., Molded Plastic Div., Taylor & Olive Sts., Elyria, Ohio
General Iron Works Co., P.O. Box 2490, Denver 1, Colo.
General Malleable Corp., 706 E Main St., Waukesha, Wis.
General Metals Corp., 550 85th Ave., Oakland, Calif.
General Metals Powder Co., 130 Ellinor Ave., Akron 5, Ohio
General Mills, Inc., Chemical Div., S Kensington Rd., Kankakee, Ill.
General Motors Corp., General Motors Bldg., Detroit, Mich.
Central Foundry Div., 37 Florence St., Saginaw, Mich.
Fabricast Div., 3rd & Monon, Bedford, Ind.
Moraine Products Div., 1420 Wisconsin Blvd, Dayton 1, Ohio
Rochester Products Div. (Ad p 409)
1000 Lexington Ave., Rochester 3, N.Y.
General Plastics Corp., 1400 N Washington St., Marion, Ind.
General Plastics Corp., 165 3rd Ave., Paterson, N.J.
General Plastics Mfg. Co., 3481 S 35th St., Tacoma 9, Wash.
General Powdered Metal Products, Inc., Holly Corp., 523 West Ave., Norwalk, Conn.
General Refractories Co., 1520 Locust St., Philadelphia 2, Pa.
General Screw Products Corp., 1190 Brooks Ave., Rochester 19, N.Y.
General Sintering Corp., 1830 N 32 Ave., Melrose Park, Ill.
General Smelting Co., 2901 E Westmoreland St., Philadelphia, Pa.
General Steel Castings Corp., 1417 State St., Granite City, Ill.
General Tire & Rubber Co., 1700 Factory Ave., Marion, Ind.
Chemical Div., 1485 Archwood, Akron 9, Ohio
Respro Div., 530 Wellington Ave., Cranston 10, R.I.
Textileather Div., 607 Madison Ave., Toledo 8, Ohio
General Veneer Mfg. Co., 8652 Otis, South Gate, Calif.
Genesee Laboratory, Inc., 16 Garden St., Auburn, N.Y.
Geometric Stamping Co., 1111 E 200th St., Cleveland 17, Ohio
George, P. D. Co., 5100 N 2nd St., St. Louis, Mo.
Georgia Iron Works, Augusta, Ga.
Georgia-Pacific Corp., Equitable Bldg., Portland, Ore.
Gering Products, Inc., N 7th St. & Monroe Ave., Kenilworth, N.J.
Gerstenslager Co., E Bowman St., Wooster, Ohio
Geuder, Paeschke & Frey Co., 324 N 15th St., Milwaukee 1, Wis.
Giant Grip Mfg. Co., 113 Osceola St., Oshkosh, Wis.
Gibb Walton Leather Co., 54th & Grays Ferry Ave., Philadelphia 43, Pa.
Gibson Electric Co. (Ad p 415)
Box 545, Belmont, Pa.
Gibson & Kirk Co., Warner & Bayard St., Baltimore 30, Md.
Gilbert & Bennett Mfg. Co., Georgetown, Conn.
Gilbert Brass Foundry Co., 5036 Farlin Ave., St. Louis 15, Mo.
Gillett & Eaton, Inc., 847 Doughty, Lake City, Minn.
Gilman Bros. Co., Gilman, Conn.
Gladding, McBean & Co., 2901 Los Feliz Blvd., Los Angeles 39, Calif.
Glamorgan Pipe and Foundry Co., P.O. Drawer 740, Lynchburg, Va.
Glasby, J. P. Mfg. Co., Inc., 1 Montgomery St., Belleville 9, N.J.
Glaskyd, Inc., Eckel Rd., Perrysburg, Ohio
Glass Laboratories, 863 65th St., Brooklyn 20, N.Y.
Glass Reinforced Plastics Corp., 405 W Sophia, Maumee, Ohio
Glastic Corp. (Ad p 290)
4321 Glenridge Rd., Cleveland 21, Ohio
Glenn, Joseph & Sons, Inc., Clifton Hts., Pa.
Glidden Co., 1717 Summer St., Hammond, Ind.
Chemicals-Pigments-Metals Div. (Ad p 391)
3901-3915 Hawkins Pt. Rd., Baltimore 26, Md.
Paint Div., 900 Union Commerce Bldg., Cleveland 14, Ohio
Globe Imperial Corp., Plastic-Seal Div., 2038 Kishwaukee, Rockford, Ill.
Globe Industries, Inc., Supermet Div. (Ad p 420)
1460 Cincinnati St., Dayton 8, Ohio
Globe Paint Works, Inc., P.O. Box 36, Williamsport, Pa.
Globe Steel Abrasive Co., 238 1st Ave., Mansfield, Ohio
Globe Union, Inc., Centralab Div. (Ad p 291)
946 E Keefe Ave., Milwaukee 1, Wis.
Glo-Brite Products, Inc., 6415 N California Ave., Chicago 45, Ill.
Glover Machine Works, Butler St., Marietta, Ga.
Gluntz Brass & Aluminum Foundry Co., 10815 Harvard Ave., Cleveland 5, Ohio
Gold Leaf & Metallic Powders, Inc., 145 Nassau St., New York, N.Y.
Goldsmith Bros. Smelting & Refining Co., 111 N Wabash Ave., Chicago 2, Ill.
Gomar Mfg. Co., Inc., 1501 W Blancke St., Linden, N.J.
Goodrich, B.F. Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio
Hood Rubber Co. Div., 99 Nichols Ave., Watertown, Mass.
Sponge Products Div., Shelton, Conn.
Goodrich, B.F. Industrial Products Co., Marietta, Ohio
Goodrich-Gulf Chemicals, Inc. (Ad p 254)
3121 Euclid Ave., Cleveland 15, Ohio
Goodyear Tire & Rubber Co., 1144 E Market St., Akron 16, Ohio
Gordon Chemicals, Inc., 500 A St., Wilmington 99, Del.
Goshen Rubber Co., Inc. (Ad p 396)
1525 S 19th St., Goshen, Ind.
Goslin Birmingham Mfg. Co., Inc., 3521 10th Ave. N, Birmingham 1, Ala.
Gossett and Hill Co., 7185 W Bloomingdale, Chicago 35, Ill.
Gotham Plastics Corp., 220 E 134 St., New York 51, N.Y.
Gowanda Furnaces, Inc., 7 Palmer St., Gowanda, N.Y.
Grace, W.R. & Co., 7 Hanover Sq., New York, N.Y.
Dewey & Almy Chemical Co. Div., 62 Wittemore Ave., Cambridge 40, Mass.
Polymer Chemicals Div., 225 Allwood Rd., Clifton, N.J.
Grafton Foundry Co., 1003 Bridge St., Grafton, Wis.
Graham, James Co., 293 Wooster St., New Haven Conn.
Gra-Iron Foundry Corp., 501 S 12th Ave., Marshalltown, Iowa
Grammes, L.F. & Sons, Inc., 380 Union St., Allentown, Pa.
Grand Haven Stamped Products Co., Griffen & Madison Sts., Grand Haven, Mich.
Grand Rapids Brass Co., 420 50th St., SW, Grand Rapids 8, Mich.
Grand Rapids Varnish Corp., 1350 Steele St., SW, Grand Rapids, Mich.
Grand Sheet Metal Products Co., Consumer Products Div., 2055 Ruby St., Melrose Park, Ill.
Granite City Steel Co., 20th & Madison Aves., Granite City, Ill.
Graphite Metallizing Corp., 1058 Nepperhan Ave., Yonkers 3, N.Y.
Graphite Products Corp., Trumbull County, Brookfield, Ohio
Graphite Specialties Corp. (Ad p 288)
64th St. & Pine Ave., Niagara Falls, N.Y.
Grass, M.J. Machine Products Co., 19 Northampton St., Buffalo 9, N.Y.
Graton & Knight Co., 356 Franklin St., Worcester, Mass.
Graver Tank & Mfg. Co., Inc., 4809 Tod Ave., East Chicago, Ind.
Gray-Syracuse, Inc., W Seneca St., Manlius, N.Y.

Great American Industries, Inc., Rubatex Div., Bedford, Va.
Great Lakes Carbon Corp., 18 E 48th St., New York 17, N.Y.
Grede Foundries, Inc., 1320 S 1st St., Milwaukee 1, Wis.
Green Bay Foundry & Machine Works, 401 S Broadway, Green Bay, Wis.
Green, A.P. Fire Brick Co., Mexico, Mo.
Green River Steel Corp., P.O. Drawer 637, Owensboro, Ky.
Greenback Industries, Inc., 2527 W Maple Rd., Birmingham, Mich.
Greene, G.G. Corp., Box 900, Warren, Pa.
Greene Mfg. Co., 1028 Douglas Ave., Racine, Wis.
Greenlee Foundry Co., 4600 W 14th St., Chicago 50, Ill.
Green-Walker Galvanizing Co., Inc., 5002 Jefferson Highway, New Orleans 21, La.
Greer Stop Nut Co., 2620 W Flournoy St., Chicago 12, Ill.
Gregg Metal Products Inc., 1333 N 9th St., Milwaukee 5, Wis.
Gregory Industries Inc., Nelson Stud Welding Div., 28th St. & Toledo Ave., Lorain, Ohio
Gregory Thomas Galvan Works, 4900 Grand Ave., Maspeth 78, N.Y.
Grems Mfg. Co., 5635 S 6th St., Klamath Falls, Ore.
Grey, C.M. Industries, Inc., 358 Central Ave., East Orange, N.J.
Gries Reproducer Corp. (Ad pp 388, 424, 460)
153 Beechwood Ave., New Rochelle, N.Y.
Grigoleit Co., 740 E North, Decatur, Ill.
Grimes Mfg. Co., Plastic Research Products, 200 Beech St., Urbana, Ohio
Grimm Foundry Co., Inc., Chimney Rock Rd., Bound Brook, N.J.
Grip Nut Co. (Ad p 460)
Broad & Maple Sts., South Whitley, Ind
Groov-Pin Corp., 1125 Hendricks Causeway, Ridgefield, N.J.
Gross, Willard N., Inc., 224 Highland Ave., Westmont, Collingswood, N.J.
Guarantee Specialty Mfg. Co., 9651 Carr Ave., Cleveland 8, Ohio
Guilfoy Cornice Works, 1234 Howard St., San Francisco 3, Calif.
Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J.
Gunite Foundries Corp., 302 Peoples Ave., Rockford, Ill.
Gustin-Bacon Mfg. Co., 210 W 10th St., Kansas City 5, Mo.

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H & H Foundry Machine Co., P.O. Box 238, Jeanette, Pa.
H & H Screw Products, Inc., 570 Elk St., Buffalo 10, N.Y.
H. & H. Screw Products Mfg. Co., 1883 Mineral Spring Ave., North Providence 11, R.I.
H & H Tube & Mfg. Co., 263 N Forman, Detroit 17, Mich.
H & K Machine Service Co., Inc., 6229 Bartmer Ave., St. Louis, Mo.
H. K. Metal Craft Mfg. Corp., 3775 10th Ave., New York, N.Y.
H-P Products, Inc., 510 W Broad St., Louisville, Ohio
H & R Industries, 344 E Walnut St., Nazareth, Pa.
HPL Mfg. Co. 15210 Miles Ave., Cleveland 28, Ohio
Haber, 864 W North Ave., Chicago 22, Ill.
Hack, J.H. Mfg. Co., 7049 Lyndon Ave., Detroit 21, Mich.
Hadley Bros.-Uhl Co., 514 Clavary Ave., St. Louis 15, Mo.
Haffner Bros. Co., Hopple St. Central Pkwy., Cincinnati 25, Ohio
Hagstoz, T.B. & Son, 709 Sansom, Philadelphia 6, Pa
Haigh Mfg. Co., 225 E Grand River, Brighton, Mich.
Halex Corp., 26302 W 7 Mile Rd., Detroit 40, Mich.
Hall C.P. Co., 414 S Broadway, Akron 8, Ohio
Hall Mfg. Co., 175 Linden St., Hackensack, N.J.
Haller, Inc., 16580 Northville Rd., Northville, Mich.
Hallstead Foundry, Inc., Main St., Hallstead, Pa.
Halogen Insulator & Seal Corp., 9960 Pacific Ave., Franklin Park, Ill.
Hamilton Die Cast, Inc., 240 N B St., Hamilton, Ohio
Hamilton Foundry & Machine Co., 1551 Lincoln Ave., Hamilton, Ohio
Hamilton Watch Co., Precision Metals Div., Lancaster, Pa.
Hampden Brass & Aluminum Co., 262 Liberty St., Springfield, Mass.
Hampton Mfg. Co., 111 Cedar St., New Rochelle, N.Y.
Handy & Harman (Ad p 457)
82 Fulton St., New York 38, N.Y.
Hanford Foundry Co., 119 S Arrowhead Ave., San Bernardino, Calif.
Hauser Products, Inc., 4034 N Kolmar Ave., Chicago 41, Ill.
Hanlon-Gregory Galvanizing Co., 5515 Butler St., Pittsburgh 1, Pa.
Hanovia Chemical Mfg. Co., 1 Central Ave., East Newark, N.J.
Hansell-Elcock, 485 W 23rd Pl., Chicago 16, Ill.
Harbot Die Casting Corp., 52 E Centre St., Nutley, N.J.
Harcast Co., Inc., 620 E Glenolden Ave., Glenolden, Pa.
Hardinge Mfg. Co., 240 Arch St., York, Pa.
Hardman, H. V. Co., Inc., 577 Cortlandt St., Belleville 9, N.J.
Hardy, Charles, Inc., 420 Lexington Ave., New York 17, N.Y.
Hardy Mfg. Corp., W Pearl St., Union City, Ind.
Harnischfeger Corp., 4400 W National Ave., Milwaukee 46, Wis.
Harper, H.M. Co., 8200 Lehigh Ave., Morton Grove, Ill.
Harrington & King Perforating Co., Inc. (Ad p 406)
5671½ Fillmore St., Chicago 44, Ill.
Harris, Benjamin & Co., 11th & State Sts., Chicago Hts., Ill.
Harrisburg Steel Co., 110 E 42nd St., New York 17, N.Y.
Harsco Corp., 3200 Guardian Bldg., Detroit 26, Mich.
- Ainsworth-Precision Castings Co. Div., 3200 Guardian Bldg., Detroit 26, Mich
- Taylor-Wharton Co., High Bridge, N.J.

Harshaw Chemical Co., 1945 E 97th St., Cleveland 6, Ohio
Hartford Electric Steel Corp., 540 Flatbush Ave., Hartford 10, Conn.
Hartglas Co., 1302 Expressway Dr., Toledo 8, Ohio
Hartwell, H.N. & Son, Inc., Park Square Bldg., 31 St. James St., Boston 16, Mass.
Harvey Aluminum Sales, Inc., 19200 S Western Ave., Torrance, Calif.
Harvill Corp., 6251 W Century Blvd., Los Angeles 45, Calif.
Harvin & Co., Box 83, Federal St., Kenilworth, N.J.
Harwood Screw Products, Inc., 1620 E Pleasant St., Springfield, Ohio
Haskelite Mfg. Corp., 701 Ann St., NW, Grand Rapids, Mich.
Hassall, John Inc., Westbury, Long Island, N.Y.
Hastings & Co., Inc., 2314 Market St., Philadelphia 3, Pa.
Hauser Products, Inc., 4034 N Kolmar Ave., Chicago 41, Ill.
Haveg Industries, Inc., 900 Greenbank Rd., Wilmington 8, Del.
Hawkeye Rubber Mfg. Co., 915 Shaver Road NE, Cedar Rapids, Iowa
Hawkridge Bros. Co., 303 Congress St., Boston 10, Mass.
Hawley Products Co., 333 N 6th St., St. Charles, Ill.
Haws Refractories Co., 407 Main St., Johnstown, Pa.
Hay, James E. Co., Inc., 244 Smith St., Lowell, Mass.
Hayden Mica Co., Inc., Main St., Wilmington, Mass.
Hayden Wire Works, Inc., P.O. Box 146, West Springfield, Mass.
Hayes Adhesive Co., Inc., Union Blvd. at Brown Ave., St. Louis 15, Mo.
Hayman, Michael & Co., 856 E Ferry St., Buffalo 11, N.Y.
Hays Mfg. Co., 80 W 12th St., Erie, Pa.
Haywilk Galvanizing Inc., P.O. Box 372, Harvey, La.
Hazledine, E.T. Co., 231 S 1st St., Terre Haute, Ind.
Headford Bros. & Hitchins Foundry Co., 1502 Westfield Ave., Waterloo, Iowa
Headly Mfg. Co., 4376 W Ogden Ave., Chicago 23, Ill.
Heatbath Corp., P.O. Box 78, Springfield 1, Mass.
Heil Process Equipment Corp., 12901 Elmwood Ave., Cleveland 11, Ohio
Heintz Mfg. Co., Front St. & Olney Ave., Philadelphia 20, Pa.
Held, O.P. Inc., 761 Nepperhan Ave., Yonkers 3, N.Y.
Heli-Coil Corp., Shelter Rock Lane, Danbury, Conn.
Heller, A.B. Screw Products, Inc., 14571 Lesure Ave., Detroit 27, Mich.
Heller Tool Co., Heller Dr., Newcomerstown, Ohio
Helmick Foundry-Machine Co., P.O. Box 71, Fairmont, W. Va.
Hendrick Mfg. Co., 50 Dundaff St., Carbondale, Pa.
Henefelt Precision Products, 1630 Herald Ave., Cincinnati 12, Ohio
Henrite Products Corp., Ironton, Ohio
Heppenstall Co., 4620 Hatfield St., Pittsburgh 1, Pa.
Hercules Fastener Co., 2722 N Clybourn St., Chicago 14, Ill.
Hercules Powder Co., Inc. (Ad pp 264-265)
Delaware Trust Bldg., Wilmington 99, Del
Heresite & Chemical Co., Manitowoc, Wis.
Herker Screw Products, Inc., 4924 N 125th St., Butler, Wis.
Herman Machine & Tool Co., Tallmadge, Ohio
Hersey Metal Products, Inc., Derby, Conn.
Hettleman, K. & Sons, Inc., 9th & Patapsco Aves., Baltimore 25, Md.
Hewitt, John Foundry Co., 15-29 Sherman Ave., East Newark, N.J.
Hewitt-Robins, Inc., 666 Glenbrook Rd., Stamford, Conn.
Hexcel Products, Inc., 2332 4th St., Berkeley, Calif.
Heyplan Mfg. Co., E Michigan Ave., Kenilworth, N.J.
Hibben & Co., 9376 S Ewing Ave., Chicago, Ill.
Hica, Inc., 1431 W 59th St., Shreveport, La.
Hicks Corp., Hyde Park Ave., Boston, Mass.
Higbie Mfg. Co., Avon Tube Div., Klein Rd., Rochester, Mich.
High Vacuum Equipment Corp., 2 Churchill Rd., Hingham, Mass.
Hi-Grade Alloy Corp., 1236 S Talman Ave., Chicago 8, Ill.
Hilfinger Corp., 1800 Westwood Ave., Toledo 7, Ohio
Hills-McCanna Co., 3025 N Western Ave., Chicago 18, Ill.
Hilo Varnish Corp., Industrial Finishes Div., Carpenter-Morton Co., 376 3rd St., Everett 49, Mass.
Himmel Bros. Co., 1409 Dixwell Ave., Hamden, Conn.
Hi-Shear Rivet Tool Co., 2600 W 247th St., Torrance, Calif.
Hitchiner Mfg. Co., Inc., P.O. Box 350, Milford, N.H.
Hitemp Wires, Inc., 1200 Shames Dr., Westbury, N.Y.
Hobart Bros. Co., 1221 Hobart Rd., Troy, Ohio
Hobbs, Clinton E. Co., 203 Chelsea St., Everett 49, Mass.
Hodges, William & Co., Inc., 1627 N American St., Philadelphia 2, Pa.
Hodgman Rubber Co., Tripp St., Framingham, Mass.
Hodgson Foundry Co., 2012 W 13th St., Chicago 8, Ill.
Hoeganaes Sponge Iron Corp. (Ad p 422)
Riverton, N.J.
Hoffman Bronze & Aluminum Casting Co., 1000 Addison Rd., Cleveland 3, Ohio
Hofford Varnish Co., Inc., Broad & 14th Sts., Carlstadt, N.J.
Hohwieler Rubber Co., Inc., 32 W Bridge St., Morrisville, Pa.
Hokin Aluminum Co., 142nd St. & Cottage Grove, Dolton, Ill.
Hollingsworth & Vose Co., Washington St., East Walpole, Mass.
Holo-Krome Screw Corp., P.O. Box 98, Elmwood Branch, Hartford 10, Conn.
Holt Products Co., Walnut St., Holt, Mich.
Home Rubber Co., 30 Woolverton Ave., Trenton, N.J.
Homestead Valve Mfg. Co., P.O. Box 348 Coraopolis, Pa.
Hommel, O. Co., P.O. Box 475, Pittsburgh 30, Pa.
Hoofer Mfg. Co., 544 W Lake St., Chicago 6, Ill.
Hooker Chemical Corp., 51 47th St., Niagara Falls, N.Y.
- **Durez Plastics Div. (Ad pp 252-253)**
  1967 Walck Rd., North Tonawanda, N.Y.

Hoover Co., Die Casting Div., 101 E Maple St., North Canton, Ohio
Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8, Mich.
Houdaille Industries, Inc., Fairmount Tool & Forging, Inc. Sub., 10611 Quincy Ave., Cleveland 6, Ohio
Houghton, E.F. & Co., 303 W Lehigh Ave., Philadelphia 33, Pa.
Houghton Laboratories (Ad p 248)
322 Houghton Ave., Olean, N.Y.
Houston Blow Pipe & Sheet Metal Works, P.O. Box 1692, Houston 1, Tex.
Howard Foundry Co., 1700 N Kostne Ave., Chicago 29, Ill.
Howe Sound Co., Austenal Co. Div. 224 E 39th St., New York 16, N.Y
Hoyt, Charles D. Co., Inc., 1118 Forest Ave., Mishawaka, Ind.
Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich.
Hudsar, Inc., 567 Wilson Ave., Newark 5, N.J.

Hudson Cush-N-Foam Corp., Lake Ave. & Saw Mill River Rd., Yonkers, N.Y.

Hudson Screw Machine Products Co., 4500 W Augusta Blvd., Chicago 51, Ill.

Hudson Wire Co., Pequot Wire Cloth Co. Div., 35 Hoyt St., Norwalk, Conn.

Hughes Glue Co., 3500 St. Aubin Ave., Detroit 7, Mich.

Hughes Tool Co., 5425 Polk Ave., P.O. Box 2539, Houston 1, Tex.

Hull, R.O. & Co., Inc., 1300 Parsons Ct., Rocky River 16, Ohio

Humphrey Castings, Inc., 3944 Riley St., San Diego 10, Calif.

Hungerford Plastics Corp., P.O. Box 376, Morristown, N.J.

Hunt Screw & Mfg. Co., 4117 N Kilpatric Ave., Chicago 41, Ill.

Hunter Spring Co., 1 Spring Ave., Lansdale, Pa.

Hunt-Spiller Mfg. Corp., 383 Dorchester Ave., Boston 82, Mass.

Huron Automatic Screw Co., P.O. Box 66, Port Huron, Mich.

Huron Forge & Machine Co., 9041 Alpine Ave., Detroit 4, Mich.

Hussey, C.G. & Co., 2850 2nd Ave., Pittsburgh 19, Pa.

Hyde, A.L. Co., Main St., Grenloch, N.J.

Hydrawlik Co., 131-137 E 1st St., Roselle, N.J.

Hydroforming Co. of America, 7400 W Lawrence Ave., Chicago 31, Ill.

Hydrometals, Inc., Illinois Zinc Co. Div., 2959 W 47th St., Chicago 32, Ill.

Hy-Level Screw Products Co., 2615 Scranton Rd., Cleveland 13, Ohio

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I-F Mfg. Co., New Philadelphia, Ohio

Ideal Can Co., 68 Vine St., Everett 49, Mass.

Ideal Metal Products Co., 4842 W Kinzie St., Chicago 44, Ill.

Illinois Forge, Inc., Rock Falls, Ill.

Illinois Iron & Bolt Co., Carpentersville, Ill.

Illinois Precise Casting Co., 903 N Spaulding Ave., Chicago 51, Ill.

Illinois Smelting & Refining Co., 3637 S Albany Ave., Chicago 32, Ill.

Illinois Tool Works, 2511 N Keeler Ave., Chicago, Ill.

Fastex Div., 195 Algonquin Rd., Des Plaines, Ill.

Shakeproof Div., St. Charles Rd., Elgin, Ill.

Imco Container Corp., 75th & Cleveland Sts., Kansas City, Mo.

Impact Extrusions, Inc., 2102 Calumet Rd., Valparaiso, Ind.

Impax, Inc., P.O. Box 5841, Ferguson 21, Mo.

Improved Seamless Wire Co., 775 Eddy St., Providence 5, R.I.

Imsande Screw Products Co., 3517 Cardiff Ave., Cincinnati 9, Ohio

Indar Corp., Indianapolis, Ind.

Independence Stove & Mfg. Co., Haywood & Cottage Sts., Independence, Mo.

Independent Galvanizing Co., 37 Verona Ave., Newark 4, N.J.

Indiana Brass Co., Inc., P.O. Box 113, Frankfort, Ind.

Indiana Forge & Machine Co., 3468 Watling St., East Chicago, Ind.

Indiana Steel Products Co., Valparaiso, Ind.

Indiana Steel & Wire Co., Inc., 700 S Council St., Muncie, Ind.

Indium Corp. of America (Ad p 154)
1676 Lincoln Ave., Utica 1, N.Y.

Indus Corp., 1815 Madison Ave., Indianapolis 25, Ind.

Industrial Chromium Corp., 109 Lyman St., Holyoke, Mass.

Industrial Equipment Co., 115 Ohio St., Minster, Ohio

Industrial Metal Protectives, Inc., 401 Homestead Ave., Dayton 8, Ohio

Industrial Mica Corp., 223 S Van Brunt St., Englewood, N.J.

Industrial Pipe & Supply Co., 5100 W 16th St., Cicero 50, Ill.

Industrial Plastic Fittings Co., 3891 W 150th St., Cleveland 11, Ohio

Industrial Plastics Corp., 816 W Beardsley Ave., Elkart, Ind.

Industrial Polychemical Service, P.O. Box 423, Gardena, Calif.

Industrial Precision Products, 325 N Hayne Ave., Chicago 12, Ill.

Industrial Rayon Corp., 500 5th Ave., New York 36, N.Y.

Industrial Screw Machine Products Co., 1654 W 57th Place, Chicago, Ill.

Industrial Stainless Steels, Inc., 255 Bent St., Cambridge 41, Mass.

Industrial Synthetics Corp., 225 North Ave., Garwood, N.J.

Industrial Tectonics, Inc., 3686 Jackson Rd., Ann Arbor, Mich.

Industrial-Ferguson Foundry Corp., Route 22, Union, N.J.

Ingalls Iron Works Co., 620 4th Ave., Birmingham, Ala.

Ingersoll-Rand Co., Phillipsburg, N.J.

Ingram-Richardson, Inc., 1460 Jefferson Rd., Frankfort, Ind.

Ingram-Richardson Mfg. Co., P.O. Box 191, Beaver Falls, Pa.

Inland Mfg. Co., 1108 Jackson St., Omaha 2, Neb.

Inland Steel Co., 30 W Monroe St., Chicago 3, Ill.

Inshield Die & Stamping Co., 1931 Manhattan Blvd., Toledo 8, Ohio

Inspiration Consolidated Copper Co., 25 Broadway, New York 4, N.Y.

Instrument Parts Corp., Snowden Ave. & Water St., Ossining, N.Y.

Instrument Specialties Co., Inc. (Ad p 381)
244 Bergen Blvd., Little Falls, N.J.

Insulation Mfrs. Corp., 565 W Washington Blvd., Chicago 6, Ill.

Insulation Products Co., P.O. Box 5679, Pittsburgh 8, Pa.

Interchemical Corp., 67 W 44th St., New York 36, N.Y.

Angier Adhesives Div., 120 Potter St., Cambridge 42, Mass.

Finishes Div., 224 McWhorter St., Newark 5, N.J.

Interlake Mfg. Co., 13595 Helen Ave., Detroit 12, Mich.

International Balsa Corp., 100 Boyd Ave., Jersey City 4, N.J.

International Harvester Co., 180 Michigan Ave., Chicago, Ill.

International Minerals and Metals Corp., 11 Broadway, New York 4, N.Y.

Wisconsin Steel Co. Div., 180 N Michigan Ave., Chicago 1, Ill.

International Nickel Co., Inc., 67 Wall St., New York 5, N.Y.

Platinum Metals Div., 67 Wall St., New York 5, N.Y.

International Optical Co., Inc., 47 Urban Ave., Westbury, L.I., N.Y.

International Packings Corp. (Ad p 423)
Bristol, N.H.

International Packings Corp., Bristol, N.H.

International Paper Co., Long-Bell Div., Longview, Wash.

International Powder Metallurgy Co., Inc., 439 W Main St., Ridgway, Pa.

International Silver Co., Eyelet Specialty Div., 50 State St., Waterbury, Conn.

Interstate Drop Forge Co., 4051 N 27th St., Milwaukee 16, Wis.

Investment Casting Co., 60 Brown Ave., Springfield, N.J.

Iowa Malleable Iron Co., 9th & Kirkwood Sts., Fairfield, Iowa

Ironton Fire Brick Co., Box 536, Ironton, Ohio

Irvington Form & Tank Corp., 20 Vesey St., New York 7, N.Y.

Irwin-Sensenich Corp., P. O. Box 311, Irwin, Pa.

Industrial & Furnace Car Div., P.O. Box 311, Irwin, Pa.

Isaacson Iron Works, 8531 E Marginal Way, Seattle 14, Wash.

Isocyanate Products, Inc., 900 Wilmington Rd., New Castle, Del.

Iten Fibre Co., Box 20, Ashtabula, Ohio

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Jackson Auto Radiator, 1515 Altgeld St., Chicago 14, Ill.

Jackson Steel Products, Inc., 32 Rodney St., Brooklyn 11, N.Y.

James Hill Mfg. Co., 20 Gordon Ave., Providence 5, R.I.

Jamestown Finishes, 125 Blackstone Ave., Jamestown, N.Y.

Jamestown Malleable Iron Corp., 3444 Blackstone Ave., Jamestown, N.Y.

Jamison Plastic Corp., 1255 Newbridge Rd., North Bellmore, L.I., N.Y.

Janney Cylinder Co., 7401 State Rd., Philadelphia 36, Pa.

Jaques Co., 67 Batterymarch St., Boston 10, Mass.

Jarco Metal Products, Portland Ave., Westbury, L.I., N.Y.

Jarl Extrusions, Inc. (Ad p 412)
Linden Ave., East Rochester, N.Y.

Jasco Aluminum Products Co., New Hyde Park, N.Y.

Jasper Lacquer Co., Inc., Vine St., Jasper, Ind.

Jelliff, C.O. Mfg. Corp., Pequot Rd., Southport, Conn.

Jelrus Precision Casting Corp., 136 W 52 St., New York, N.Y.

Jema-American, Inc., 181 South St., Newark 5, N.J.

Jersey Plastic & Die Casting Co., 151 Shaw Ave., Irvington, N.J.

Jessop Steel Co., 500 Green St., Washington, Pa.

Jet Specialties Co., Inc., 941 N Eastern Ave., Los Angeles, Calif.

Jobbins, William F. Inc., Aurora, Ill.

Johns-Manville Corp., 22 E 40th St., New York 16, N.Y.

Dutch Brand Div., 7800 Woodlawn Ave., Chicago 19, Ill.

Johnson, A. & Co., Inc., 21 West St., New York 6, N.Y.

Johnson Bronze, S Mill St., New Castle 6, Pa.

Johnson Metal Hose, Inc., 10 Sperry St., Waterbury 20, Conn.

Johnson Plastic Corp., Box 312, Chagrin Falls, Ohio

Johnson Rubber Co., 111 Vine St., Middlefield, Ohio

Johnson, S.C. & Son, Inc., Racine, Wis.

Johnson Steel and Wire Co., Inc., 53 Wiser Ave., Worcester, Mass.

Johnston & Funk Titanium Corp., W Kemrow Ave., Wooster, Ohio

Johnstone Foundries, Inc., P.O. Box 549, Grove City, Pa.

Jolens Metal Products Co., 224 Sussex Ave., Newark 4, N.J.

Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30, Pa.

Stainless & Strip Div. (Ad pp 94-95)
Stainless—P.O. Box 4606, Detroit 34, Mich.; Strip—1939 Teeghly St., Youngstown 1, Ohio

Jordan Co., 51st St. & Merrimac Ave., Chicago 38, Ill.

Jordan Machine Products, Inc., 3611 St. Aubin Ave., Detroit 7, Mich.

Jordan-Rogers Co., 640 N Cypress, Orange, Calif.

Joseff-Hollywood Co., 129 E Providencia, Burbank, Calif.

Joslyn Mfg. & Supply Co., 155 N Wacker Dr., Chicago 6, Ill.

Joslyn Pacific Co., 5100 District Blvd., Los Angeles 11, Calif.

Joslyn Stainless Steels, 155 N Wacker Dr., Chicago 6, Ill.

Joymont Plastics, Inc., 710 S State St., Girard, Ohio

Judd Industries, Inc., 3148 W 32 St., Cleveland 9, Ohio

Judsen Rubber Works, Inc., 4107 W Kinzie St., Chicago 24, Ill.

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K-D Mfg. Co., 435 Shaffer St., Cleburne, Tex.

K. & L. Plating Co., 535 E Mifflin St., Lancaster, Pa.

K S H Plastics, Inc., Hwy. 30, High Ridge, Mo.

KSM Products, Inc., Yale & Woodland Aves., Merchantville 8, N.J.

Kaiser Aluminum & Chemical Sales Inc., 919 Michigan Ave., Chicago 11, Ill.

Kaiser Steel Corp., 1924 Broadway, Oakland 12, Calif.

Kamin Die Casting & Mfg. Co., 3315 N Knox, Chicago 41, Ill.

Kanawha Mfg. Co., Charleston, W. Va.

Kansas City Hay Press Co., 801 Weeswether Rd., Kansas City 5, Mo.

Kanthal Corp., Amelia Pl., Stamford, Conn.

Katelman Foundry & Mfg. Co., 238 S 11th St., Council Bluffs, Iowa

Kawecki Chemical Co., 220 E 42nd St., New York 17, N.Y.

Kawneer Co., 1105 N Front St., Niles, Mich.

Kay-Bee Machine Products Co., 2776 S 34 St., Milwaukee 15, Wis.

Kay-Brunner Steel Products, Inc., 999 Meridian Ave., Alhambra, Calif.

Kaye-Tex Mfg. Corp., Kaykor Industries, Inc. Div., Yardville, N.J.

Keasbey & Mattison Co., Butler Ave., Ambler, Pa.

Keen Foundry Co., Inc., E Main & E Jerr Sts., Griffith, Ind.

Kees, F.D. Mfg. Co., 700 Park St., Beatrice, Neb.

Kelite Corp., Bldg. 15, 81 Industrial Rd., Berkeley Heights, N.J.

Keller Products, Inc., 37 Union, Manchester, N.H.

Kelley Mfg. Co., 4800 Clinton Dr., P.O. Box 17, Houston 1, Tex.

Kelly Foundry Co., 1704 Wharton St., Pittsburgh 3, Pa.

Kelsey-Hayes Co., 3600 Military Ave., Detroit, Mich.

Utica Metals Div., Utica 4, N.Y.

- Kendall Co., Walpole, Mass.
  - Andrews-Alderfer Div., 1055 Home Ave., Akron 10, Ohio
  - Kendall Mills Div., Walpole, Mass.
  - Polyken Sales Div., 309 W Jackson Blvd., Chicago 6, Ill.
- Kenmore Machine Products, Inc., 15 Depew Ave., Lyons, N.Y.
- **Kennametal, Inc. (Ad p 301)** Lloyd Ave., Latrobe, Pa.
- Kennecott Copper Corp., 161 E 42nd St., New York, N.Y.
  - Chase Brass & Copper Co. Sub., Waterbury 20, Conn.
  - Okonite Co. Sub., 220 Passaic St., Passaic, N.J.
- Kennedy Automatic Products, Inc., 406 S Linden St., Marshall, Mich.
- Kenosha Automatic Products Co., P.O. Box 630, Kenosha, Wis.
- Kensico Tube Co., Hubbell & RR Aves., Mt. Kisco, N.Y.
- Kent Castings Corp., 200 Garden St., Grand Rapids 7, Mich.
- Kent County Galvanizing Co., 15 Earlham Way, Hillsgrove 5, R.I.
- Keolyn Plastics, Inc., 2731 N Pulaski Rd., Chicago 39, Ill.
- Kerr, R.W. Plastic Co., 220 S Burlington Ave., Hastings, Neb.
- Kerr-Lakeside Industries, Inc., 21850 St. Clair Ave., Cleveland 17, Ohio
- Kester Solder Co., 4201 Wrightwood Ave., Chicago 39, Ill.
- Kewaunee Engineering Corp., N Main St., Kewaunee, Wis.
- Keystone Carbon Co., 1935 State St., St. Marys, Pa.
- Keystone Drawn Steel Co., Main & Bridge Sts., Spring City, Pa.
- Keystone Forging Co., Northumberland, Pa.
- Keystone Plastics, Inc., 2331 Morris Ave., Union, N.J.
- Keystone Refining Co., Inc., Garden St., Philadelphia 37, Pa.
- Keystone Steel & Wire Co., Peoria 7, Ill.
- Kicknaefer Mfg. Co., 901 S 2nd St., Milwaukee 4, Wis.
- Kidd Drawn Steel Co., Aliquippa, Pa.
- King, Alfred B. Co., Devine St., North Haven, Conn.
- King Fifth Wheel Corp., 2915 N 2nd Ave., Philadelphia 33, Pa.
- King Laboratories, Inc., 127 Solar St., Syracuse 3, N.Y.
- King-Seeley Corp., 720 Norris St., Ypsilanti, Mich.
  - **Almco, Queen Products Div. (Ad p 339)** 36 Front St., Albert Lea, Minn.
  - Central Specialty Div., 720 Central Ave., Ypsilanti, Mich.
- Kingsport Foundry & Mfg. Corp., E Sullivan & Main Sts., Kingsport, Tenn.
- Kinkead Industries, Inc., 5860 N Pulaski Rd., Chicago 30, Ill.
- Kiowa Corp., Marshalltown, Iowa
- Kirchhof Patent Co., Inc., Dietze Bldg., 60-64 Union St., Newark 5, N.J.
- Kirk, F.J. Co., Inc., 140 Brook St., Clinton, Mass.
- Kirk, Morris P. & Son, 2700 S Indiana St., Los Angeles 23, Calif.
- Kirk & Blum Mfg. Co., 3215 Forrer St., Cincinnati 9, Ohio
- Kirkhill Rubber Co., Brea, Calif.
- Kish Industries, Inc., 1301 N Turner St., Lansing 6, Mich.
- Kleiner Metal Specialties, Inc., P.O. Box 185, Dunellen, N.J.
- Klincher Locknut Corp., 2153 Hillside Ave., Indianapolis 18, Ind.
- Kling Metal Spinning & Stamping Co., 245-247 Centre St., New York 13, N.Y.
- Klinzing, A.F. Co., Inc., 921 A 2nd St., Milwaukee 4, Wis.
- Klise Mfg. Co., 50 Cottage Grove St., Grand Rapids 2, Mich.
- Knapp Mills, Inc., 23-17 Borden Ave., Long Island City 1, N.Y.
- Knight, Maurice A., 171 Kelly Ave., Akron 9, Ohio
- Knoedler Chemical Co., 651 High St., Lancaster, Pa.
- **Knowlton Bros., Inc. (Ad p 292)** 215 Factory, Watertown, N.Y.
- Kobel, W.R. Sheet Metal Products, 148 W 21st St., Ogden, Utah
- Koch, H. & Sons, P.O. Box 125, Corte Madera, Calif.
- Koehler Mfg. Co., 395 Lincoln St., Marlboro, Mass.
- Koehring Co., Milwaukee, Wis.
- Kohn Engineering Corp., 8830 S Telegraph Rd., Taylor Center, Mich.
- Kopp Glass, Inc., Swissvale, Pittsburgh 18, Pa.
- Koppers Co., Inc., Koppers Bldg., Pittsburgh 19, Pa.
  - **Plastics Div. (Ad pp 216-217)** Koppers Bldg., Pittsburgh 19, Pa.
- Korhumel Steel and Aluminum Co., 2424 Oakton St., Evanston, Ill.
- Koster-Keunen Mfg. Co., Inc., Bourne Blvd., Sayville, N.Y.
- Kovar, John R. Mfg. Co., Inc., Bridge Square, Anoka, Minn.
- Koven, L.O. & Brother, Inc., 154 Ogden Ave., Jersey City 7, N.J.
- Kralay Plastic Pipe Co., Inc., 4710-20 E Washington Blvd., Los Angeles 22, Calif.
- Kramer, C.P. Co., 9230 W Belmont Ave., Franklin Park, Ill.
- Kramer, H. Co., Ajax Metal Div., 46 Richmond St., Philadelphia 23, Pa.
- Kramer Bros. Foundry Co., 17 Dell St., Dayton 4, Ohio
- Kraus Research Labs, Cockeysville, Md.
- Kroh Wagner, 2331 N Pulaski Rd., Chicago 39, Ill.
- Krone, Paul Die Casting Co., 1811 N Kostner Ave., Chicago 39, Ill.
- Kropp Forge Co., 5301 W Roosevelt Rd., Chicago 50, Ill.
- Krueger Fabricating Co., Inc., 257 W Badger Road, Madison 5, Wis.
- Krueger & Hudepohl, Inc., 1041 Evans St., Cincinnati 4, Ohio
- Kuhn & Jacob Molding & Tool Co., 1200 Southard Ave., Trenton 8, N.J.
- Kurz Kasch, Inc., 1421 S Broadway, Dayton 1, Ohio
- Kuss, R.L. & Co., Inc., 739 Foulke Ave., Findlay, Ohio
- Kutztown Foundry & Machine Corp., Kutztown, Pa.
- Kwikset Powdered Metal Products, 516 E Santa Ana St., Anaheim, Calif.

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- L. O. F. Glass Fibers Co., 1810 Madison Ave., Toledo 1, Ohio
  - Corrulux Div., 410 Holmes Rd., P.O. Box 20026, Houston 25, Tex.
- L. & R. Mfg. Co., 577 Elm St., Arlington, N.J.
- Laboratory Equipment Corp., Hilltop Rd. & Lakeview Ave., St. Joseph, Mich.
- Laclede Steel Co., 1380 Arcade Bldg., St. Louis 1, Mo.
- Laconia Malleable Iron Co., 71 Water St., Laconia, N.H.
- Lacquer Products, Inc., 9001 Kinsman Rd., Cleveland 4, Ohio
- Ladish Co., 5481 S Packard Ave., Cudahy, Wis.
- La France Precision Casting Co., 29th & McKean St., Philadelphia 45, Pa.
- Lake City Malleable Co., 5000 Lakeside Ave., Cleveland 14, Ohio
- Lake Erie Foundry Co., 143 Fillmore Ave., Buffalo 10, N.Y.
- Lake Mfg. Corp., 1070 East St., New Britain, Conn.
- Lakeland Industries, Isle, Minn.
- Lakeside Bronze, Inc., 90 Arthur St., Buffalo 7, N.Y.
- Lakeside Malleable Casting Co., 1333 23rd St., Racine, Wis.
- Lakewood Metal Products, Inc., 39 Cherry Ave., Waterbury 20, Conn.
- Laminated Plastex Corp., 1427 W North St., Springfield, Ohio
- Laminated Shim Co., 1600 Union St., Glenbrook, Conn.
- Laminated Veneers Co., 102nd St. & 92nd Ave., Richmond Hill, N.Y.
- Lamson Products Co., 1128 Poplar Pl., Seattle 44, Wash.
- Lamson & Sessions Co., 5000 Tiedeman Rd., Cleveland 9, Ohio
- Lamtex Industries, Inc., 66 Brooklyn Ave., Westbury, L.I., N.Y.
- Lancaster Glass Corp., 220 W Main St., Lancaster, Ohio
- Lancaster Malleable Castings Co., 1170 Lititz Ave., Lancaster, Pa.
- Landau, J. & Co., Inc., Carlstadt, N.J.
- Lang-Scharmann & Co., 206 W 1st St., Marshfield, Wis.
- Langsenkamp, F.H. Co., 229 E South St., Indianapolis, Ind.
- Langsenkamp-Wheeler Brass Works, Inc., South & Harmon Sts., Indianapolis, Ind.
- Lansdale Porcelain Enamel Corp., 5th & Iron, Lansdale, Pa.
- Lansing Stamping Co., Box 838, 1167 S Pennsylvania Ave., Lansing 4, Mich.
- La Porte Foundry Co., 301 Truesdell Ave., La Porte, Ind.
- Larkin Specialty Mfg. Co., 915 Linden Ave., South San Francisco, Calif.
- Larson, W.O. Foundry Co., 799 Barchard, Grafton, Ohio
- Larson, Charles E. & Sons, Inc., 2645-65 N Keeler Ave., Chicago 39, Ill.
- Larson Tool & Stamping Co., Olive St., Attleboro, Mass.
- La Salle Steel Co., P.O. Box 6800-A, Chicago 80, Ill.
- Latrobe Die Casting Co., Latrobe, Pa.
- **Latrobe Steel Co. (Ad p 93)** Latrobe, Pa.
- Lattimer Foundry and Machine Co., Lattimer Mines, Pa.
- Lattner Bros. Machining Co., 650 E Troy, Ferndale 20, Mich.
- Latwaitis, Ernest A., 102-09 Remsen Pl., Howard Beach 14, N.Y.
- Lavelle Rubber Co., 424 N Wood St., Chicago 22, Ill.
- Lavin, R. & Sons, Inc., 3426 S Kedzie Ave., Chicago 23, Ill.
- Lawrence, L. Co., Inc., 292 Halsey St., Newark 2, N.J.
- Lawrence Copper & Bronze Co., W New Castle St., Zilenpole, Pa.
- Lawrence Laboratory, 1668 Euclid St., Santa Monica, Calif.
- Lawrenceville Screw Co., 4920 Harrison St., Pittsburgh 1, Pa.
- Lawson, F.H. Co., Evans & Whateley Sts., Cincinnati 4, Ohio
- Lawton, C.A. Co., Broadway, DePere, Wis.
- Laystrom Mfg. Co., 3900 W Palmer St., Chicago 47, Ill.
- Lea Mfg. Co., 16 Cherry Ave., Waterbury 20, Conn.
- Leach & Garner Co., Industrial Div., Leach & Garner Bldg., Attleboro, Mass.
- Leader Iron Works, Inc., 2108 N Jasper St., Decatur, Ill.
- Leake Engineering Co., P.O. Box 715-MS, Monroe, Mich.
- **Lebanon Steel Foundry (Ad p 402)** 1st Ave. & E. Lehmen St., Lebanon, Pa.
- LeBaron, E.L. Foundry, Box 746, Brockton, Mass.
- Lee Bros. Foundry Co., Inc., P.O. Box 231 Anniston, Ala.
- Lee Rubber & Tire Corp., Hector St., Conshohocken, Pa.
  - Republic Rubber Div., 1410 Albert, Youngstown 1, Ohio
- Leed, H.A. Co., 1685 Diswell Ave., Hamden, Conn.
- Lehigh, Inc., 1500 Lehigh Dr., Easton, Pa.
  - Lehigh Foundries Div., 1500 Lehigh Dr., Easton 1, Pa.
- Lehigh Structural Steel Co., Allentown, Pa.
- Leitelt Bros., Inc., 7721-31 S Chicago Ave., Chicago 19, Ill.
- **Lenape Hydraulic Pressing & Forging Co. (Ad p 396)** Box 536, West Chester, Pa.
- Lester Castings Inc., Cannon & Aurora Rds., Bedford Heights, Ohio
- Letukas Foundry, Upland, Ind.
- Levinson Steel Co., S 20th & Wharton St., Pittsburgh 3, Pa.
- Lewin-Mathes Co., 1111 Chouteau Ave., St. Louis 2, Mo.
- **Lewis, G. B. Co. (Ad p 394)** 4026 Montgomery St., Watertown, Wis.
- Lewis, J.P. Co., Plastic Products Div., Beaver Falls, N.Y.
- Lewis Bolt & Nut Co., 504 Malcolm Ave. SE, Minneapolis 14, Minn.
- Lewis & Saunders, Lakeport, N.H.
- Lewistown Foundry & Machine Co., 16 Elizabeth St., Lewistown, Pa.
- Liberty Foundry Co., 7600 Vulcan St., St. Louis 11, Mo.
- Light Metals Corp., 1211 Monroe Ave. NW, Grand Rapids, Mich.
- Light Metals, Inc., 1100 E 24th St., Indianapolis 5, Ind.
- Lignum-Vitae Products Corp., 98 Boyd Ave., Jersey City 4, N.J.
- Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio
- Lincoln Foundry Corp., 2525 E 49th St., Los Angeles 58, Calif.
- Lincoln Iron Works, 255 West St., Rutland, Vt.
- Lincoln Machine Parts Corp., 732 E 144th St., New York 54, N.Y.
- Lincoln Mfg. Co., Inc., 2617 W Fletcher St., Chicago 18, Ill.
- Lincoln Molded Plastics, Inc., Corwin & Clinton Sts., Circleville, Ohio
- Lincoln Steel Corp., 315 W 9th St., Lincoln 1, Neb.
- Lindell Drop Forge Co., 2830 S Logan Blvd., Lansing 3, Mich.
- Linden & Co., 80 Baker St., Providence 5, R.I.
- Linderme Tube Co., 1500 219th St., Cleveland 17, Ohio
- Link-Belt Co., Prudential Plaza, Chicago 1, Ill.
- Linton Precision Casting Co., 917 N Nappanee St., Elkhart, Ind.
- Litemetal Dicast, Inc., 1927 Wildwood Ave., Jackson, Mich.
- Lithcote Corp., 5000 W Lake St., Melrose Park, Ill.
- **Lithium Corp. of America, Inc. (Ad p 147)** 400 2nd Ave. S, Minneapolis 1, Minn.
- Litho-Strip Corp., M. M. Young Div., 4800 S Kilbourn Ave., Chicago 32, Ill.
- Little Foundries, Inc., 2431 Conners St., Port Huron, Mich.
- Little Falls Alloys, Inc., 189 Caldwell Ave., Paterson, N.J.
- Littleford Bros. Inc., 453 E Pearl St., Cincinnati 2, Ohio

Addresses of Suppliers

Littlestown Hardware & Foundry Co., Inc., Charles St., Littlestown, Pa.
Livingston-Tyler Products, 501 N 5th St., Hamilton, Ohio
Lloyd & Scott Brass Foundry, Inc., 2206 Tatnall St., Wilmington 99, Del.
Lock Joint Tube Co., Inc., 1400 Riverside Dr., South Bend 24, Ind.
Locke Machine Co., 971 E 63rd St., Cleveland 3, Ohio
Lockhart Iron & Steel Co., River Ave., McKees Rocks, Pa.
Lockport Mfg. Co., 1102 Collins St., Joliet, Ill.
Lockport Steel Fabricators, Inc., P.O. Box 67, Lockport, Ill.
Lodge Mfg. Co., RR & 6th, South Pittsburg, Tenn.
Lodi Iron Works, Inc., 820 S Sacramento, Lodi, Calif.
Loeffler, J.M. Co., Machine & Brass Works, 149 N 4th St., Philadelphia 6, Pa.
Loewenthal Metals Corp., 947 Cullerton St., Chicago 8, Ill.
Lone Star Plastics Co., Inc., 124 Roberts Cutoff, Fort Worth, Tex.
Long Beach Iron Works, 2100 W Anaheim St., Long Beach 13, Calif.
Long Foundry Co., Hoquiam, Wash.
Lorain Automatic Screw Machine Co., Inc., 218 Connecticut, Lorain, Ohio
Lorain Brass Co., 639 Broadway, Lorain, Ohio
Loranger Mfg. Corp., 12-38 Clark St., Warren, Pa.
Lord Mfg. Co., Special Products Div., 1635 W 12th St., Erie, Pa.
Los Angeles Galvanizing Co., Vernon Branch, P.O. Box 58411, Los Angeles 58, Calif.
Los Angeles Steel Casting Co., 6100 S Boyle Ave., Los Angeles 58, Calif.
Lowe Bros. Co., 424 E 3rd St., Dayton 2, Ohio
Lubenow, Arthur Co., 2015 S Kinnickinnic Ave., Milwaukee 7, Wis.
Lucas-Milhaupt Engineering Co., 5051 S Lake Dr., Cudahy, Wis.
Ludlow Valve Mfg. Co., Inc., Hudson River at Adams St., Troy, N.Y.

Lukens Steel Co. (Ad pp 76-77)
Coatesville, Pa.

Lumen Bearing Co., 197 Lathrop St., Buffalo 12, N.Y.
Luminous Resins, Inc., 166 W Washington St., Chicago 2, Ill.
Lundberg Screw Products Co., 2101 W Willow St., Lansing 4, Mich.
Lundquist Tool & Mfg. Co., Inc., 57 Jackson St., Worcester 8, Mass.
Lunn Laminates, Inc., Oakwood & W 11th Sts., Huntington Station, N.Y.
Luria Engineering Co., 1745 Easton Ave., Bethlehem, Pa.
Lus-Trus Corp., 884 Railroad St., Ypsilanti, Mich.
Lux Clock Mfg. Co., Inc., 95 Johnson St., Waterbury 20, Conn.
Luzerne Rubber Co., Muirhead Ave., Trenton 7, N.J.
Lynchburg Foundry Co., Castings Div., Courtland Bldg., Lynchburg, Va.
Lyndon Machine Products Co., Inc., 18564 Fitzpatrick Ave., Detroit 28, Mich.
Lynn Casting Corp., 3014 Floyd St., Burbank, Calif.

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M & S Mfg. Co., 220 Main St., Hudson, Mich.
Maas & Waldstein Co., 2121 McCarter Hwy., Newark 2, N.J.
Macaulay, H.C. Foundry Co., 811 Carlton St., Berkeley 10, Calif.
MacDermid Inc., 526 Huntingdon Ave., Waterbury 20, Conn.
Machine Products Corp., 125 Hollier Ave., Dayton, Ohio
Machinery Forging Co., 5430 Hamilton Ave., Cleveland 14, Ohio
Machinery Products Corp., 2020 N Major Ave., Chicago 39, Ill.
Machinery Products Co. of Lancaster, 317 E Fulton St., Lancaster 10, Pa.
Mac-It Parts Co., 275 E Liberty St., Lancaster, Pa.
Mack Molding Co., Wayne, N.J.
MacKenzie-Walton Co., 478 Pawtucket Ave., Pawtucket, R.I.
MacLean-Fogg Lock Nut Co., 5535 N Wolcott St., Chicago 40, Ill.
Madison Foundry Co., 935 Addison Rd., Cleveland 3, Ohio
Madison Kipp Corp., 201 Waubesa St., Madison 10, Wis.
Magic Chemical Co., 121 Crescent St., Brockton 2, Mass.
Magic Iron Cement Co., 5403 Bower Ave., Cleveland 27, Ohio
Magirl Foundry & Furnace Co., 413 E Oakland Ave., Bloomington, Ill.
Magline, Inc., 1960 Mercer, Pinconning, Mich.
Magna Mfg. Co., Inc., 4th Ave., Haskell, N.J.
Magnesium Co. of America, 5222 Indianapolis Blvd., East Chicago, Ill.
Magnesium Elektron, Inc., 630 5th Ave., New York 20, N.Y.
Magnesium Products of Milwaukee, Inc., 748 W Virginia St., Milwaukee 4, Wis.
Magnetic Core Corp., John & Lawrence Sts., Newburgh, N.Y.
Magnetic Powders, Inc., Fairview Ave., Johnsonburg, Pa.
Magnetic Stamping Co., Fairview Ave., Johnsonburg, Pa.
Magnode Products, Inc., P.O. Box 292, Trenton, Ohio
Magnolia Metal Co., 800 McCarter Hwy., Newark 4, N.J.
Magnuson Products Corp., 50 Court St., Brooklyn 1, N.Y.
Mahon, R.C. Co., 6565 E 8 Mile Rd., Detroit 34, Mich.
Main Screw Machine Products, Inc., 58 Lafayette St., Waterbury, Conn.
Malleable Iron Fittings Co., Branford, Conn.
Mallory, P.R. & Co., Inc., 3033 E Washington St., Indianapolis 6, Ind.
Mallory, P.R. Plastics, Inc., 3670 Milwaukee Ave., Chicago 41, Ill.
Mallory-Schwarzkopf Metals, Inc., 320 Yonkers Ave., Yonkers, N.Y.

Mallory-Sharon Metals Corp. (Ad p 151)
980 Warren Ave., Niles, Ohio

Malone Bronze Powder Works, Inc., Malone, N.Y.
Malone Metal Powders, Inc., Rte. 202, Flemington, N.J.
Maloney, F.H. Co., 2301 Texas Ave., P.O. Box 1777, Houston 1, Tex.
Malvern Brick & Tile Co., P.O. Box 415 Malvern, Ark.
Manco Products, Inc., 2401 Schaefer Rd., Melvindale, Mich.
Manganese Steel Forge Co., Richmond St. & Castor Ave., Philadelphia 34, Pa.
Manhattan Adhesives Corp., 425 Greenpoint Ave., Brooklyn 22, N.Y.
Mannesmann-Easton Plastic Products Co., Inc., 900 Line St., Easton, Pa.
Manor Die Cast Corp., P.O. Box 386, Bedford, Ohio
Mansfield Brass & Aluminum Corp., 287 N Diamond St., Mansfield, Ohio
Mansol Ceramics Co., 140 Little St., Belleville 9, N.J.
Mantel Screw Products Co., 3200 W Vliet St., Milwaukee 8, Wis.
Manufacturers Corp., 104 Ausdale Ave., Mansfield, Ohio
Manufacturers & Fabricators, Inc., Filbert St., Elyria, Ohio
Manufacturers Iron Foundry, Inc., 785 Union Ave., Bridgeport, Conn.
Manufacturers Service, Inc., 11440 Brookpark Rd., Cleveland 30, Ohio
Marblette Corp., 37-31 30th St., Long Island City 1, N.Y.
Markal Co., 3052 W Carroll Ave., Chicago 12, Ill.
Marlane Development Co., Inc., 153 E 26th St., New York 10, N.Y.
Marquette Mfg. Co., Inc., 307 E Hennepin Ave., Minneapolis, Minn.
Marquette Metal Products Co., 1145 Galewood Dr., Cleveland 10, Ohio
Marsco Mfg. Co., 2901 S Halsted St., Chicago 8, Ill.
Marshall Car Wheel & Foundry Co., Inc., 605 Greenwood Ave., Marshall, Tex.
Martin Rubber Co., Inc., Long Branch Ave., Long Branch, N.J.
Masco Screw Products Co., 12825 Ford Rd., Dearborn, Mich.
Masland Duraleather Co., Amber & Willard Sts., Philadelphia 34, Pa.
Mason Envelope Co., Inc., 536 Broadway, New York 12, N.Y.
Masonite Corp., 111 W Washington St., Chicago 2, Ill.
Massachusetts Screw Mfg. Co., 9 W 3rd St., South Boston 27, Mass.
Massillon Steel Casting Co., Box 388, Massillon, Ohio
Master Chrome Service, Inc., 5709 Herman Ave., Cleveland 2, Ohio
Matthiessen & Hegeler Zinc Co., 9th & Sterling Sts., La Salle, Ill.
May, Inc., 5803 Alice Rd., Houston 5, Tex.
Maynard Mfg. Co., 22755 Shakespeare Ave., East Detroit, Mich.
Mayon Plastics, 415 17th Ave. N, Hopkins, Minn.
Mayville Metal Products Co., 104 Highland St., Mayville, Wis.
Maze, W.H. Co., 1207 Water St., Peru, Ill.
McCarter Iron Works, Inc., Norristown, Pa.
McCrady Refractories, Inc., P.O. Box 11566, Pittsburgh 38, Pa.

McDanel Refractory Porcelain Co. (Ad p 292)
510 9th Ave., Beaver Falls, Pa.

McDougall Butler Co., Inc., 2929 Main St., Buffalo 14, N.Y.
McDowell Mfg. Co., 301 Stanton Ave., Pittsburgh 9, Pa.
McDowell-Wellman Cos., 113 St. Clair Ave. NW, Cleveland 14, Ohio
McGean Chemical Co., 1040 Midland Bldg., Cleveland 15, Ohio
McGraw-Edison Co., 5201 W 65th St., Chicago, Ill.
  Illinois Edison Porcelain Div., Macomb, Ill.
  Line Material Industries Div., N Burson St., East Stroudsburg, Pa.
Mc Gregor-Michigan Corp., 5818 Rivard, Detroit 11, Mich.
McInnes Steel Co., 441 E Main St., Corry, Pa.
McKay Co., 481 McKay Bldg., Pittsburgh, Pa.
McKinney Mfg. Co., 1715 Liverpool St., Pittsburgh 33, Pa.
McLanahan & Stone Corp., 200 Wall St., Hollidaysburg, Pa.
McLouth Steel Corp., 300 S Livernois Ave., Detroit 17, Mich.
McMahon Bros. Machine Works, Inc., 3200 S 61st Court, Cicero 50, Ill.
McNally Pittsburg Mfg. Co., P.O. Drawer D., Pittsburg, Kan.
Meaden Screw Products Co., 3010 S Kilbourn Ave., Chicago 23, Ill.
Meadville Malleable Iron Co., Meadville, Pa.

Mearl Corp. (Ad p 330)
124 E 40th St., New York 16, N.Y.

Measuregraph Co., 4245 Forest Park Blvd., St. Louis 8, Mo.
Mechanical Art Works, Inc., 96-98 Monroe St., Newark 5, N.J.
Mechanical Felt & Textiles Co., 50 W 18th St., Weehawken, N.J.
Mechanical Leathers, Inc., 2204 E Butler St., Philadelphia 37, Pa.
Mechanical Plating Co., 1500-26 W Hubbard St., Chicago 22, Ill.
Mechanical Rubber Products Co., Warwick, N.Y.
Mechanical Steel Tubing Corp., 500 Barry St., New York 59, N.Y.
Medico Industries, Inc., 11-13 Tompkins St., Pittston, Pa.

Meehanite Metal Corp. (Ad pp 378, 379)
714 North Ave., New Rochelle, N.Y.

Meeker Foundry Co., Newark 4, N.J.
Meier Screw Products & Mfg. Co., 19361 Sherwood Ave., Detroit, Mich.
Melco Wire Products, 4407 San Fernando Rd., Glendale 4, Calif.
Melling Forging Co., 1709 Thompson St., Lansing 3, Mich.
Melray Mfg. Co., 9511 W. River St., Schiller Park, Ill.
Mercast Mfg. Corp., 2620 1st St., La Verne, Calif.
Merit Screw Machine Products Co., Inc., 4847 W Lake St., Chicago 44, Ill.
Merit Specialties Co., Inc., 203-205 E Davis St., St. Louis 11, Mo.
Merix Chemical Co., 2234 E 75th St., Chicago 49, Ill.
Merrimac Brass, 22 High St., Merrimac, Mass.
Merriman Bros., Inc., 185 Amory St., Boston 30, Mass.
Merz Machine & Tool Works, 920 N Main St., Crown Point, Ind.
Mesa Plastics Co., 11751 Mississippi St., Los Angeles 25, Calif.
Metal Carbides Corp., 107 E Indianola Ave., Youngstown 5, Ohio
Metal Coating Corp., 1215 W 37th St., Chicago 9, Ill.
Metal Finishers, Inc., 78 S Franklintown Rd., Baltimore 23, Md.
Metal Goods Corp., 6211 Cedar Springs Rd., Dallas 35, Tex.
Metal Goods Corp., 8800 Page Blvd., St. Louis 14, Mo.
Metal Hydrides, Inc., 12 Congress St., Beverly, Mass.
Metal Mold Magnesium Corp., 95 Hamilton St., Cedarburg, Wis.
Metal Parts & Stamping Co., 1120 Eastern Ave., Cincinnati, Ohio
Metal Powder Products, Inc., P.O. Box 189 M, Logan, Ohio
Metal Textile Corp., 647 E 1st Ave., Roselle, N.J.
Metal Trims, Inc., Livingston Rd., Jackson, Miss.
Metal & Thermit Corp., Woodbridge Ave. at Randolph Ave., Rahway, N.J.
Metal-Cladding, Inc., P.O. Box 544, North Tonawanda, N.Y.
Metallized Carbon Co., 19 S Water St., Ossining, N.Y.
Metallizing Co. of America, 3520 W Carroll Ave., Chicago 24, Ill.
Metallizing Co. of Los Angeles, Inc., 1233 S Boyle Ave., Los Angeles 23, Calif.

Metallizing Engineering Co., Inc. (Ad pp 148, 330, 336)
Prospect Ave., Westbury, N.Y.

In contacting suppliers, please mention the Materials Selector

Metallurgical Products Co., 35th & Moore Sts., Philadelphia, Pa.
Metalplate Co., Inc., 757 North 44th St., Birmingham 6, Ala.
Metals & Controls Corp., General Plate Div., 50 Forest St., Attleboro, Mass.
Metals Disintegrating Co. (Ad p 415)
P.O. Box 290, Elizabeth, N.J.
Metalweld, Inc., Protective Coating Div., Scotts Lane & Abbottsford Ave., Philadelphia, Pa.
Metaplast Process, Inc., 34-51 56th St., Woodside, N.Y.
Met-L-Wood Corp. (Ad p 32)
6755 W 65th St., Chicago 38, Ill.
Metropolitan Iron Foundry, 890 Metropolitan Ave., Brooklyn 11, N.Y.
Meyer, J. & Sons, Inc., 4321 N 4th St., Philadelphia 40, Pa.
Mica Corp., 4031 Elenda St., Culver City, Calif.
Mica Fabricating Co., 53 Central Ave., Rochelle Park, N.J.
Micacraft Products, Inc., 701 McCarter Hwy., Newark, N.J.
Michelman Chemicals, Inc., 6316 Wiehee Rd., Cincinnati, Ohio
Michigan Chrome & Chemical Co., 8615 Grinnell Ave., Detroit 13, Mich.
Michigan Leather Products Co., 6307 E Lafayette Ave., Detroit 7, Mich.
Michigan Plastic Products, Inc., Robbins Rd. Grand Haven. Mich.
Michigan Powdered Metal Products Co., 456 E Cady St., Northville, Mich.
Michigan Seamless Tube Co., South Lyon, Mich.
Michigan Wire Cloth Co., 2100 Howard St., Detroit 16, Mich.
Mico Corp., 4031 Elenda, Culver City, Calif.
Micro Metallic Corp., 30 Sea Cliff Ave., Glen Cove, N.Y.
Micro Products Corp., 4116-18 Olive St., St. Louis 8, Mo.
Micro-Metals Co., 52 E Montecito Ave., Sierra Madre, Calif.
Midland Adhesive & Chemical Corp., 2600 Goodrich, Ferndale 20, Mich.
Midland Industrial Finishes Co., E Water St., Waukegan, Ill.
Midland Pipe & Supply Co., 2829 S 61st St., Cicero 50, Ill.
Mid-States Rubber Products, Inc., 1230 Race St., Princeton, Ind.
Mid-States Steel & Wire Co., Crawfordsville, Ind.
Midvale-Heppenstall Co., Nicetown, Philadelphia 40, Pa.
Midwest Molding & Mfg. Co., Gurnee, Ill.
Midwest Piping Co., Inc., 2nd & Barry Sts., St. Louis 4, Mich.
Midwest Plastic Products Co., 1801 Chicago Rd., Chicago Heights, Ill.
Midwest Precision Castings Co., 1070-903 Quincy Ave., Cleveland 6, Ohio
Mid-West Screw Products Co., 3662 Park Ave., St. Louis 10, Mo.
Midwest Screw Products, Inc., 1641 Colt Ave., East Cleveland 12, Ohio
Midwest Sintered Products Corp., 13606 S Halsted St., Chicago 27, Ill.
Midwest Stamping & Mfg. Co., Krauss Rd., Bowling Green, Ohio
Mid-West Wire Products Co., Inc., 2555 Fenkell Ave., Detroit 38, Mich.
Midwestern Foundries, Inc., 614 E Quincy, Garrett, Ind.
Milford Automatics, Inc., 1553 Boston Post Rd., Milford 15, Conn.
Milford Rivet & Machine Co., Milford, Conn.
Milled Screw Product Co., 2016-2026 W Lake St., Chicago 12, Ill.
Miller Co., 99 Center St., Meriden, Conn.
Millers' Brass Fitting Co., Inc., 30 Main St., Brooklyn 1, N.Y.
Milwaukee Aluminum & Brass Foundry, 643 S 2nd St., Milwaukee 4, Wis.
Milwaukee Die Casting Co., 4134 N Holton St., Milwaukee 12, Wis.
Milwaukee Forge & Machine Co., 1532 E Oklahoma Ave., Milwaukee 7, Wis.
Milwaukee Machine Products Co., 3889 N 1st St., Milwaukee 12, Wis.
Milwaukee Malleable & Grey Iron Works, 2773 S 29th St., Milwaukee 46 Wis.
Milwaukee Stamping Co., 800-S 72nd St., Milwaukee 14, Wis.
Milwaukee Valve Co., 2375 S. Burrell St., Milwaukee 7, Wis.
Mimosa Corp., 211 Covert Ave., Evansville, Ind.
Minimax Co., 5905 N Clark St., Chicago 26, Ill.
Minneapolis Electric Steel Castings Co., 3800 NE 5th St., Minneapolis 21, Minn.
Minneapolis Honeywell Regulator Co., 2753 4th Ave., S, Minneapolis 8, Minn.
Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.
  Adhesives, Coatings & Sealers Div., 411 Piquette Ave., Detroit 2, Mich.
  Chemical Div., 900 Bush Ave., St. Paul 16, Minn.
  Irvington Varnish & Insulator Div., Irvington N.J
  Mica Insulator Div., 797 Broadway, Schenectady 1, N.Y.
  Reinforced Plastics Div., 900 Fauquier Ave., St. Paul 6, Minn.
  Zenith Plastics Co. Div., Box 91, Gardena, Calif.
Minnesota Paints, Inc., 1101 S 3rd St., Minneapolis 15, Minn.
Minnesota Plastics Corp., 45 E Maryland Ave., St. Paul 3, Minn.
Minnesota Rubber Co., 3630 Wooddale Ave., Minneapolis 16, Minn.
Miracle Adhesives Corp., 250 Pettit Ave., Bellmore, L.I., N.Y.
Mirro Aluminum Co., 1512 Washington St., Manitowoc, Wis.
Misco Precision Casting Co., 116 W Gibbs, Whitehall, Mich.
Misner Corp., 940 N 23rd St., Omaha 2, Neb.
Missouri Boiler & Sheet Works, 23rd & Papin Sts., St. Louis 3, Mo.
Missouri Diecasting Co., 1411 N 17, St. Louis 6, Mo.
Missouri Rolling Mill Corp., 6800 Manchester Ave., St. Louis 10, Miss.
Missouri Steel Castings Co., 905 E 3rd St., Joplin, Mo.
Mitchell & Scott Machine Co., Inc., 1841 Ludlow Ave., Indianapolis 7, Ind.
Mitchell-Bradford Chemical Co., Wampus Lane, Milford, Conn.
Mobay Chemical Co., 1815 Washington Rd., Pittsburgh 34, Pa.
Mobile Paint Mfg. Co., Inc., 854 S Conception St., Mobile, Ala.
Moccasin Bushing Co., 2000 Chestnut St., Chattanooga 8, Tenn.
Moczik Tool & Die Works, 9511 Grinnell, Detroit 13, Mich.
Model Brass Co., Inc., 232-40 E Decatur St., Decatur, Ill.
Modern Brass Foundry & Mfg. Co., 157 Thurman St., Columbus 6, Ohio
Modern Plastics Corp., 489 N Shore Dr., Benton Harbor, Mich.
Modern Plating Corp., 121-129 S Hancock Ave., Freeport, Ill.
Modern Screw Products Co., 2307 N 9th St.. St. Louis 6. Mo.
Modiglass Fibers, Inc., P.O. Box 86, Bremen, Ohio
Moldcast Products, Inc., Pacific St., Newark 5, N.J.
Molded Fiber Glass Co., 4401 Benefit Ave., Ashtabula, Ohio
Moldex, 747 5th Ave., New York 22, N.Y.
Moline Iron Works, 130 2nd, Moline, Ill.
Moline Malleable Iron Co., St. Charles 5, Ill.
Molybdenum Corp. of America, Washington, Pa.
Monarch Aluminum Mfg. Co., 9205 Detroit Ave., Cleveland 2, Ohio
Monarch Products Co., Leake Stamping Div., 1259 E 1st St., Monroe, Mich.
Monarch Tool & Mfg. Co., 105 E 4th St., Covington, Ky.
Mono-Sol Corp., 407 County Line Rd., Gary, Ind.
Monroe Steel Castings Co., 917 W Front, Monroe, Mich.
Monsanto Chemical Co., 600 Monsanto Ave., Springfield, Mass.
  Organic Chemicals Div., Lindbergh & Olive St. Rd., St. Louis 24, Mo.
  Plastics Div., Springfield 2, Mass.
Montague Machine Co., 15th St., Turners Falls, Mass.
Monteath, J.H. Co., 2504 Park Ave., New York, N.Y.
Moody Machine Products Co., Inc., 42 Dudley St., Providence 5, R.I.
Moore, George W., Inc., 100 Beaver St., Waltham 54, Mass.
Moore, Samuel & Co., Mantua, Ohio
Moore Dry Dock Co., Adeline St. Oakland 23, Calif.
Morganite, Inc., 3302 48th Ave., Long Island City 1, N.Y.
Morningstar-Paisley, Inc., 630 W 51st St., New York 19, N.Y.
Morrell, George Corp., P.O. Box 155, Muskegon Heights, Mich.
Morrison Steel Products, Inc., 601 Amherst St., Buffalo 7, N.Y.
Morrisville Foundry Co., Inc., Morrisville, Vt.
Morse, Fred W. Co., 309 S Main St., Providence 3, R.I.
Mosinee Paper Mills Co., Mosinee, Wis.
Mount Vernon Die Casting Corp., Southfield Ave., Stamford, Conn.
Mount Vernon Furnace & Mfg. Co., Mount Vernon, Ill.
Moxness Products, Inc. (Ad p 407)
1914 Indiana St., Racine, Wis.
Muehlstein, H. & Co., Inc., 60 E 42nd St., New York 17, N.Y.
Mueller Brass Co. (Ad p 397)
1925 Lapeer Ave., Port Huron, Mich.
Mueller Machine Products, Inc., 3807 S Packard Ave., Milwaukee 7, Wis.
Multiple Extrusions, Inc., 1150-1200 E 8th St., Winona, Minn.
Muncie Malleable Foundry Co., E Highland Ave., Muncie, Ind.
Muncie Metal Spinning, Inc., 3000 S Hackley St., Muncie, Ind.
Mundt, Charles & Sons, 53 Fairmount Ave., Jersey City 4, N.J.
Murray, A.B. Co., Inc., P.O. Box 476, Elizabeth, N.J.
Murray Tube Works, Inc., P.O. Box 476, Elizabeth, N.J.
Muskegon Piston Ring Co., Sparta Foundry Div., Sparta, Mich.
Mycalex Corp. of America (Ad p 303)
125 Clifton Blvd., Clifton, N.J.
  Synthetic Mica Co. Div., 20 Passaic Ave., Caldwell, N.J.
Mystik Adhesive Products, Inc., 2635 N Kildare Ave., Chicago 39, Ill.

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Nalge Co., Inc., P.O. Box 365, Rochester 2, N.Y.
Napoleon Products Co., 410 Filmore St., Napoleon, Ohio
Narmco Resins & Coatings Co., 600 Victoria St., Costa Mesa, Calif.
Narragansett Boiler Works, Inc., 614 S Main St., Providence 3, R.I.
National Acme Co., 170 E 131st St., Cleveland 8, Ohio
National Aluminum Co., 1133 Alum Creek Dr., Columbus 9, Ohio
National Aluminum Co., Inc., 1912 Edgewood Ave., Racine, Wis.
National Aluminum & Brass Foundry, Inc., 1311 W Elm St., Independence, Mo.
National Aluminum Mfg. Co., 720 Park Ave., Peoria, Ill.
National Beryllia Corp., 4501 Dell Ave., North Bergen, N.J.
National Brass Works, Inc., 2140 E 25th St., Los Angeles 58, Calif.
National Casein Co., 601 W 80th St., Chicago 20, Ill.
National Copper & Smelting Co., 1862 E 123rd St., Cleveland 6, Ohio
National Die Casting Co., 3635 W Touhy Ave., Chicago 45, Ill.
National Distillers & Chemical Corp., U. S. Industrial Chemicals Co. Div., 99 Park Ave., New York 16, N.Y.
National Electric Products Corp., 2 Gateway Center, Pittsburgh 22, Pa.
National Felt Co., 76 Summer St., Boston 10, Mass.
National Forge & Ordnance Co., Irvine, Warren County, Pa.
National Galvanizing Co., Neville Island, Pittsburgh 25, Pa.
National Gasket & Washer Mfg. Co., Inc., 124 E 25th St., New York 10, N.Y.
National Grey Iron Foundry, Belvidere, Ill.
National Iron Co., 50th Ave. W & Famsey St., Duluth 7, Minn.
National Lead Co., 111 Broadway, New York 6, N.Y.
  Doehler-Jarvis Div., 1945 Smead Ave., Toledo, Ohio
  Titanium Alloy Mfg. Div., 2950 Hyde Park Blvd., Niagara Falls, N.Y.
  Zirconium Metals Corp of America Sub. (Ad p 395)
  111 Broadway, New York 6, N.Y.
National Lead Construction Co., Inc., P.O. Box 133, Haddonfield, N.J.
National Lock Co., 1902 7th St., Rockford, Ill.
  Fastener Div., 4500 Kishwaukee, Rockford, Ill.
National Lock Washer Co., 40 Hermon St., Newark 5, N.J.
National Machine Products Co., 44225 Utica Rd., Utica, Mich.
National Malleable & Steel Castings Co., 10300 Quincy Ave., Cleveland 6, Ohio
National Mfg. Corp., 153 Fillmore Ave., Tonawanda, N.Y.
National Metal Products Co., 2 Gateway Center, Pittsburgh 22, Pa.
National Molded Products, Inc., 40 St. Marys St., St. Marys, Pa.
National Moldite Co., 250 South St., Newark 5, N.J.
National Paint & Manganese Co., Lynchburg, Va.
National Research Corp., 70 Memorial Dr., Cambridge 42, Mass.
National Screw & Mfg. Co., 2440 E 75th St., Cleveland 4, Ohio
National Starch Products, Inc., Structural Products Div., 750 3rd Ave., New York 17, N.Y.
National Steel Corp., Grant Bldg., Pittsburgh, Pa.
  Enamelstrip Corp. Sub., 20th & Hamilton Sts., Allentown, Pa.

- Great Lakes Steel Corp., Tecumseh Rd. at West Jefferson, Ecorse, Mich.
- **Weirton Steel Co. (Ad p 89)**
  Weirton, W. Va.
- National Steel & Shipbuilding Corp., Harbor Dr. & 28th St., San Diego 12, Calif.
- National Supply Co., 2 Gateway Center, Pittsburgh 22, Pa.
  - Industrial Products Div., P.O. Drawer 28, Torrance, Calif.
- National Tank Co., Wells & Sandspring Rd., Tulsa, Okla.
- National Telephone Supply Co., 5100 Superior Ave., Cleveland 3, Ohio
- **National Vulcanized Fibre Co. (Ad p 226)**
  Box 311, Wilmington 99, Del.
- **National-Standard Co. (Ad p 375)**
  601 N 8th St., Niles, Mich.
  - Athenia Steel Div., Clifton Ave., Clifton, N.J.
  - National Standard Div., 1939 Ward Rd., Niles, Mich.
  - Reynolds Wire Div., 809 E 2nd St., Dixon, Ill.
  - Worcester Wire Works Div., 70 James St., Worcester, Mass.
- National-U. S. Radiator Corp., Plastic Metals Div., 4459 Bridge St., Johnstown, Pa.
- Naugatuck Automatics, Inc., New Haven Rd., Naugatuck, Conn.
- Neenah Foundry Co., Winneconne Ave., Neenah, Wis.
- Neilson Chemical Co., 2300 Gainsboro, Detroit (Ferndale) 20, Mich.
- Nesbitt Industries, Inc., 1823 Milwaukee Ave., Chicago 47, Ill.
- Nesor Alloy Products Co., 282 Halsey St., Newark, N.J.
- New Britain Machine Co., South St., New Britain, Conn.
- New England Brass Co., 16 Parks Ave., Taunton, Mass
- New England Die Casting Co., 445 Front Ave., West Haven, Conn.
- New England Electrical Works, Inc., 365 Main St., Lisbon, N.H.
- **New England Laminates Co. (Ad p 260)**
  P.O. Box 43, 481 Canal St., Stamford, Conn.
- New England Smelting Works, Inc., 502 Union St., West Springfield, Mass.
- New England Tape Co., Inc., 40 Tower St., Hudson, Mass.
- New Haven Copper Co., Main St., Seymour, Conn.
- New Haven Screw Machine Products, Inc., 561 Boston Post Rd., Milford, Conn.
- New Jersey Aluminum Extrusion Co., Inc., Jersey Ave., New Brunswick, N.J.
- New Jersey Metals Co., 712 Rockefeller St., Elizabeth 2, N.J.
- **New Jersey Zinc Co. (Ad pp 386-387)**
  160 Front St., New York 38, N.Y.
- New Products Corp., 448 North Shore Ave., Benton Harbor, Mich.
- New York Air Brake Co., Kinney Mfg. Div., 3529 Washington St., Boston 30, Mass.
- New York Iron Roofing & Corrugating Co., Inc., 94 1st St., Jersey City 2, N. J.
- Newage Industries, Inc., 222 York Rd., Jenkinstown 3, Pa.
- Newark Wire Cloth Co., 351 Verona Ave., Newark 4, N.J.
- Newman Bros., Inc., 670 W 4th St., Cincinnati, Ohio
- Newman-Crosby Steel Co., Deane St., Pawtucket, R.I.
- Newport Steel Corp., 9th & Thomas Sts., Newport, Ky.
- Newth Rubber Co., County Rd., Barrington, R.I.
- Newton-New Haven Co., 680 3rd Ave., West Haven, Conn.
- Newtown Mfg. Co., Newtown, Conn.
- Ney, J.M. Co., Industrial Div., P.O. Box 990, Hartford 1, Conn.
- Nichols, L.O. & Son Mfg. Co., 1625 Locust St., Kansas City 8, Mo.
- Nichols Wire & Aluminum Co., 1725 Rockingham Rd., Davenport, Iowa
- Nicolet Industries, Inc., 70 Pine St., New York 5, N.Y.
- Nicoud Mfg. Co., 3220 Grand Ave., Chicago 51, Ill.
- Nigg Engineering Corp., 545 N 2nd Ave., Corina, Calif.
- Nikoh Tube Co., 5000 S Whipple St., Chicago 32, Ill.
- Nikolas, G.J. & Co., Inc., 2890 Washington Blvd., Bellwood, Ill.
- Nilsen Mfg. Co., Electronicast Div., 21 N Church St., Addison, Ill.
- Nippert Electric Products Co., 1759 W Mound St., Columbus 23, Ohio
- Nixon Nitration Works, Nixon, N.J.
- Noble & Wood Machine Co., 1st St., Hoosick Falls, N.Y.
- Noera Mfg. Co., 236 Grand St., Waterbury 20, Conn.
- Noland Tank & Galvanizing Co., 705 Merritt Ave., Nashville 4, Tenn.
- Nolte Screw Machine Products Co., 1534-36 Freeman Ave., Cincinnati 14, Ohio
- Noone Industrial Fabrics Div., Kenwood Mills, Rennselaer, N.Y.
- Nopco Chemical Co., 1st & Essex Sts., Harrison, N.J.
- Norcross, C.S. & Sons Co., Dean & Davis Sts., Bushnell, Ill.
- Norgren-Stemac, Inc., 5400 S Delaware, Littleton, Ohio
- Norrich Plastics Corp., 107-109 W 18th St., New York, N.Y.
  - Screw Machine Products Div., 107-109 W 18th St., New York, N.Y.
- North American Asbestos Corp., Board of Trade Bldg., Chicago 4, Ill.
- North American Phillips Co., Inc., Elmet Div., Lewiston, Me.
- North American Refractories Co., 1012 National City-E 6th Bldg., Cleveland 14, Ohio
- North & Judd Mfg. Co., Wilcox-Crittenden Div., Middletown, Conn.
- North Wales Foundry Co., Inc., Wessahickon Ave., North Wales, Pa.
- Northern Malleable Iron Co., 867 Forest St., St. Paul 6, Minn.
- Northern Plastics Corp., 2nd & Market St., La Crosse 9, Wis.
- Northwest Automatic Products Corp., 1770 Linden Ave., Minneapolis 3, Minn.
- Northwest Chemical Co., 9310 Roselawn Ave., Detroit 4, Mich.
- Northwest Plastics Industries, Inc., 2040 15th Ave. W, Seattle 99, Wash.
- Northwestern Machine Corp., 3014 Hadley St., St. Louis 7, Mo.
- Northwestern Steel & Wire Co., Ave. B & Wallace St., Sterling, Ill.
- **Norton Co. (Ad p 287)**
  New Bond St., Worcester 6, Mass.
- Norwalk Powdered Metals, Inc., P.O. Box 271, Muller Park, Norwalk, Conn.
- Norwich Leather Co., 685 N Main St., Norwich, Conn.
- Nosco Plastics Co., 17th & Gasgo, Erie, Pa.
- Nuclear Metals, Inc., Concord, Mass.
- Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N.Y.
- Nu-Ply Corp., Bemidji, Minn.
- Nutmeg Crucible Steel Co., Elm & Harbor Sts., Branford, Conn.
- Nutmeg Screw Machine Products Co., Wolcott Rd., Wolcott, Conn.
- Nutt-Shel Co., Inc., 2701 S Harbor Blvd., Santa Ana, Calif.
- Nylok Corp., 611 Industrial Ave., Paramus, N.J.
- Nylok-Detroit, 1100 N Woodward, Birmingham, Mich.
- Nylon Molded Products Corp., Garrettsville, Ohio
- Nyloncraft, Inc., 218 McKinley Hwy. W, Mishawaka, Ind.

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- Oak Hill Foundry & Machine Works, Box 278, Oak Hill, Ohio
- Oakes Bronze & Aluminum Co., Bronze Rd., Warren, Ohio
- **Oakite Products, Inc. (Ad p 326)**
  19 Rector St., New York 6, N.Y.
- Oakland Foundry & Machine Co., 607-621 Woodward Ave., Rochester, Mich.
- Oatey, L.R. Co., 10230 Berea Rd., Cleveland 2, Ohio
- Octagon Process, Inc., 63 Bank St., Staten Island 1, N.Y.
- Ohio Adhesives Corp., P.O. Box 466, New Philadelphia, Ohio
- **Ohio Carbon Co. (Ad p 415)**
  12508 Berea Rd., Cleveland 11, Ohio
- Ohio Forge & Machine Corp., 3010 Woodhill Rd., Cleveland 4, Ohio
- Ohio Metal Products Co., 35 N Bates St., Dayton 2, Ohio
- Ohio Nut & Bolt Co., 33 1st Ave., Berea, Ohio
- Ohio Nut & Washer Co., Box 66, Mingo Junction, Ohio
- Ohio Precision Castings, Inc., 109 Webb St., Dayton 3, Ohio
- Ohio Rubber Co., 301 Ben Hur Ave., Willoughby, Ohio
- Ohio Screw Products, Inc., 818 West St., Elyria, Ohio
- Ohio Steel Foundry Co., 1075 James St., Springfield, Ohio
- Oil City Iron Works, S 12th St. & SPRR, Corsicana, Tex.
- Olderman Mfg. Corp., P.O. Box 917, Bridgeport, Conn.
- Olds Alloys Co., 4481 Mason St., South Gate, Calif.
- Olean Electro Plating Co., 890 N 4th St., Olean, N.Y.
- Olin Mathieson Chemical Corp., 460 Park Ave., New York 22, N.Y.
  - **Aluminum Div. (Ad p 157)**
    460 Park Ave., New York 22, N.Y.
  - Metals Div., 400 Park Ave., New York 22, N.Y.
  - Packaging Div., 655 Madison Ave., New York 21, N.Y.
- Olson Mfg. Co., 100 Prescott St., Worcester 5, Mass.
- Olympic Steel Works, 151 Horton St., Seattle 4, Wash.
- Omaha Steel Works, 609 S 48th St., Omaha 6, Neb.
- Omni Products Corp., 460 4th Ave., New York 16, N.Y.
- Omni-Metal Castings, Inc., 135 11th St., Brooklyn 15, N.Y.
- Oregon Brass Works, 1127 SE 10th Ave., Portland 14, Ore.
- Oregon Metallurgical Corp., P.O. Box 484, Albany, Ore.
- Ormand Mfg. Co., Inc., 3325 Hudson Ave., Union City, N.J.
- Ostby & Barton Co., Flightex Fabrics, Inc., 148 W River St., Providence 4, R.I.
- O'Sullivan Rubber Corp., Valley Pike St., Winchester, Va.
  - Plastics Div., P.O. Box 603, Winchester, Pa.
- Ottawa Steel Products, Inc., 745 Woodlawn Ave., Grand Haven, Mich.
- Overmyer Mould Co., Inc., N Main St., Winchester, Ind.
- Owen Mfg., Inc., S State Street Rd., Litchfield, Ill.
- Owen Pattern Foundry & Mfg. Co., Inc., 710 W 22nd St., Norfolk 10, Va.
- Owens-Corning Fiberglas Corp., 608 Madison Ave., Toledo 3, Ohio
- Owens-Illinois Glass Co., Toledo, Ohio
  - Closure & Plastics Div., P.O. Box 1035, Toledo 1, Ohio
  - Kimble Glass Co. Sub., P.O. Box 1035, Telodo 1, Ohio
  - Paper Products Div., P.O. Box 1035, Toledo 1, Ohio

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- Pabst Engineering Equipment Co., Inc., 676 Pennsylvania Ave., Elizabeth 3, N.J.
- Pacific Brass Foundry of San Francisco, 251 2nd St., San Francisco 5, Calif.
- Pacific Coast Foil Co., 500 Sansome St., San Francisco, Calif.
- Pacific Foundry Co., Ltd., 3100 19th St., San Francisco, Calif.
- Pacific Molded Products Corp., 905 E 59th St., Los Angeles 1, Calif.
- Pacific Screw Products Co., 930 Linden Ave., South San Francisco, Calif.
- Pacific Sintered Metals Co., 7728 El Manor Ave., Los Angeles, Calif.
- Pacific States Steel Corp., Niles, Calif.
- Pacific Tube Co., 5710 Smithway St., Los Angeles 22, Calif.
- Paeco Rubber Co., Inc., 225 W Lake St., Ravenna, Ohio
- Page Belting Co., Concord, N.H.
- Palmyra Foundry Co., Inc., Palmyra, N.J.
- Palnut Co., Glen Rd., Mountainside, N.J.
- Pan-American Metal Products Co., Inc., 401 NW 71st St., Miami 38, Fla.
- Panther Chemical Corp., P.O. Box 711, Ft. Worth, Texas
- Paragon Die Casting Co., 5851 W Dickens Ave., Chicago 39, Ill.
- Paragon Spring Co., 4613-17 W Fulton St., Chicago 44, Ill.
- Paramount Die Casting Co., St. Joseph, Mich.
- Paramount Paint & Lacquer Co., 3411 E 15th St., Los Angeles 23, Calif.
- Park Drop Forge Co., 777 E 79th St., Cleveland 3, Ohio
- Parker, Charles Co., Hanover St., Meriden, Conn.
- Parker Appliance Co., Rubber Products Div., 17325 Euclid Ave., Cleveland 12, Ohio
- Parker & Harper Mfg. Co., 119 Dewey St., Worcester 10, Mass.
- Parker Metal Goods Co., 85 Prescott St., Worcester, Mass.
- Parker Paint Mfg. Corp., Locust & Poplar Sts., Valparaiso, Ind.
- Parker Rust Proof Co., 2177 E Milwaukee, Detroit 11, Mich.
- Parker, Stearns & Co., Inc., 300 Sheffield Ave., Brooklyn 7, N.Y
- Parker White Metal Co., 2153 McKinley Ave., Erie, Pa.

Parker-Hannifin Corp., Parker Seal Div., 17325 Euclid Ave., Cleveland 12, Ohio
Parker-Street Castings Co., Broadway & Chaincraft Rd., Cleveland 25, Ohio
Parkwood Laminates, Inc., 24 Water St., Wakefield, Mass.
Patterson Foundry & Machine Co., 41 Henene St., East Liverpool, Ohio
Pattin Mfg. Co., Box 527, Marietta. Ohio
Paulson, Thomas & Son, Inc., 450 Union St., Brooklyn 31, N.Y
Pawling Rubber Corp., Pawling, N.Y.
Payne, F.S. Co., 75 Richdale Ave., Cambridge 40, Mass.
Peasley Products, Inc., 993 Honeyspot Rd., Stratford, Conn.
Peck Spring Co., Whiting St., Plainville, Conn.
Pecora Inc., 300-400 W Sedgley Ave., Philadelphia 40, Pa.
Pee Wee Molding Corp., 1720 Atlantic Ave., Brooklyn 13, N.Y.
Peerless Alloy Co., 1445 Osage St., Denver 4, Colo.
Peerless Automatic Machine Co., 1970 W 77th St., Cleveland 2, Ohio
Peerless Industries, Inc., P.O. Box 318, Plymouth, Mich.
Peerless Products Industries, 812-14-16 N Pulaski Rd., Chicago 51, Ill.
Peerless Roll Leaf Co., Inc., 4511 New York Ave., Union City, N.J.
Peerless Wire Goods Co., Inc., 2703 Ferry St., LaFayette, Ind.
Pelron Corp., 7847 W 47th St., Lyons, Ill.
Pelton Steel Casting Co., 148 W Dewey Pl., Milwaukee 7, Wis.
Pemco Corp., Eastern & Pemco Aves., Baltimore, Md.
Pemco Wheel Co., 1872 Ravine Rd., Kalamazoo, Mich.
Penberthy Instrument Co., 4301 6th Ave. S, Seattle 8, Wash.
Pencoyd Steel & Forge Corp., 3720-40 Main St., Philadelphia 27, Pa.
Peninsular Steel Co., P.O. Box 3853, Parkgrove Sta., Detroit 5, Mich.
Penn Brass & Copper Co., 3837 W 20th St., Erie, Pa.
Penn Engineering & Mfg. Corp., Box 311, Doylestown, Pa.
Penn Extrusion Corp., 3837 W 20th St., Erie, Pa.
Penn Fibre & Specialty Co., Inc., 2024 E Westmoreland St., Philadelphia 34, Pa.
Penn Metal Co., Inc., P.O. Box 1480, Parkersburg, W. Va.
Penn Metal Co., Inc., 40 Central St., Boston 9, Mass.
Penn Steel Castings Co., Front & Penn Sts., Chester, Pa.
Pennsalt Chemicals Corp., 3 Penn Center, Philadelphia 2, Pa.
Pennsylvania Engineering Corp., P.O. Box 311, New Castle 17, Pa.
Pennsylvania Malleable Iron Corp., 712 S Prince St., Lancaster, Pa.
Pennsylvania Range Boiler Co., 24th & Ellsworth Sts., Philadelphia 46, Pa.
Penrod, Floyd & Sons Tool & Engineering Corp., 1208 W 2nd St., Muncie, Ind.
Peoria Malleable Casting Co., 2800 N Adams St., Peoria 1, Ill.
Peoria Plastic Co., East Peoria, Ill.
Pequonnock Foundry, Inc., 335 5th St., Bridgeport, Conn.
Pequot Wire Cloth Co., 35 Hoyt, Norwalk, Conn.
Perfecto Cast, 5660 Kearney Villa Rd., San Diego 11, Calif.
Perfex Plastics, Inc., 2632 S Dearborn, Chicago 16, Ill.
Perforating Industries, Inc. (Ad p 422)
Roselle, N.J.
Perkins, Henry Co., Broad St., Bridgewater, Mass.
Permacel, Inc., U. S. Hwy. #1, New Brunswick, N.J.
Permold Co., 1250 W Liberty St., Medina, Ohio
Perrin, Edward C. Co., 3rd & Grant Sts., Camden 2, N.J.
Perry Fay Co., 200 Perry Court, Elyria, Ohio
Perry Plastics, Inc., 3409 W 14th St., Erie, Pa.
Perry-Austen Mfg. Co., 250 Parkinson Ave., Staten Island 5, N.Y.
Peterson, D. J. Co., Sheboygan, Wis.
Peterson Products Corp., 4848 N River Rd., Schiller Park, Ill.
Pettibone Mulliken Corp., 4700 W Division St., Chicago 51, Ill.
Pfaudler Co., West Ave. & Clark St., Rochester 3, N.Y.
Pfister Aluminum Corp., 475 Franklin Tpke., Allendale, N.J.
Phelps Dodge Copper Products Corp., 2010 N 10th St., Philadelphia 22, Pa.
Phelps Dodge Refining Corp., 40 Wall St., New York, N.Y.
Pheoll Mfg. Co., 5700 W Roosevelt Rd., Chicago 50, Ill.
Philadelphia Asbestos Corp., 2010 N 10th St., Philadelphia 22, Pa.
Philadelphia Enameling Works, Inc., 254 N 13th St., Philadelphia 7, Pa.
Philadelphia Steel & Wire Corp., Penn St. & Belfield Ave., Philadelphia 44, Pa.
Philco Corp., Dexter Foundry Div., 501 N 8th St., Fairfield, Iowa
Phillips, F.C. Inc., 471 Washington St., Stoughton, Mass.
Phillips Chemical Co., Adams Bldg., Bartlesville, Okla.
Philrus Products Co., 135 Newark St., Newark 4, N.J.
Phoenix Die Casting Co., 21-23 Illinois St., Buffalo 3, N.Y.
Phoenix Iron & Steel Co., Front & Dock Sts., Harrisburg, Pa.
Phoenix Mfg. Co., Industry Ave., Joliet, Ill.
Phoenix Products Co., 4715 N 27th St., Milwaukee 9, Wis.
Picco, Inc., 1729 N Chico Ave., El Monte, Calif.
Pierce, F.O. Co., 2-33 50th Ave., Long Island City 1, N.Y.
Pierce Governor of Ohio, Inc., Asbestos Ave., Alliance, Ohio
Pierce & Stevens Chemical Corp., 710 Ohio St., Buffalo, N.Y.
Pilgrim Plywood Corp., Waterbury, Vt
Pioneer Aluminum Inc., 5251 W Imperial Blvd., Los Angeles 45, Calif.
Pioneer Stamped Products Co., P.O. Box 185, Roselawn Sta., Rochester 18, N.Y.
Piper Tool Co., Inc., 15930 Common Rd., Roseville, Mich.
Pittsburgh Corning Corp., 1 Gateway Center, Pittsburgh 22, Pa.
Pittsburgh Die & Casting Co., 7503 Ardmore St., Pittsburgh 18, Pa.
Pittsburgh Forgings Co., 919 Amur St., Jackson, Mich.
Pittsburgh Forgings Co., Thorn St., Coraopolis, Pa
Pittsburgh Foundry & Machine Co., 36th St., Pittsburgh 1, Pa.
Pittsburgh Plate Glass Co., 632 Ft Duquesne Blvd., Pittsburgh 22, Pa.
Fiber Glass Div. (Ad p 249)
1 Gateway Center, Pittsburgh 22, Pa.
Forbes Finishes Div., 3800 W 143rd St., Cleveland, Ohio
Pittsburgh Smelting & Refining Co., 100 W Elizabeth St., Pittsburgh 7, Pa.
Pittsburgh Steel Co., P.O. Box 118, Pittsburgh 19, Pa.
Thomas Strip Div., Grant Bldg., Pittsburgh 30, Pa.
Pittsburgh Steel Foundry Corp., P.O. Box 986, Pittsburgh 30, Pa.
Fort Pitt Steel Casting Div., 25th St., McKeesport, Pa.
Pittsburgh Tool Steel Wire Co., Monaca, Pa.
Pittsburgh Tube Co., 212 Wood St., Pittsburgh 22, Pa.
Plast-Ad Mfg. Co., 222 N Michigan St., South Bend 1, Ind.
Plastex Co., 3232 Cleveland Ave., Columbus 24, Ohio
Plastic Engineering, Inc., 8506 Lake Ave., Cleveland 2, Ohio
Plastic Masters, Inc., New Buffalo, Mich.
Plastic Materials, Inc., New South Rd., Hicksville, N.Y.
Plastic Packaging Co., 2025 W Charleston St., Chicago 47, Ill.
Plastic Pipe & Tube Corp., 224 S Mipas St., Santa Barbara, Calif.
Plastic Process Co., Inc., 10400 Aviation Blvd., Los Angeles 45, Calif.
Plastic Products Corp., 24001 Aurrora Rd., Bedford Heights, Ohio.
Plasticrafters, Inc., 1829 S 55th Ave., Cicero 50, Ill.
Plastics Engineering Co. (Ad p 242)
1607 Geele Ave., Sheboygan, Wis.
Plastiglide Mfg. Corp., 1757 Stanford St., Santa Monica, Calif.
Carroll Plastic Compounding Corp., 3122 Nebraska Ave., Santa Monica, Calif.
Pipco International Corp., 1731 Stanford St., Santa Monica, Calif.
Plax Corp., Box 1019, Hartford, Conn.
Plumb Chemical Corp., 4837 James St., Philadelphia 37, Pa.
Plume & Atwood Mfg. Co., Thomaston, Conn.
Plymouth Cordage Co., Plymouth, Mass.
Plymouth Industrial Products, Inc., 502 Indiana Ave., Sheboygan, Wis.
Pohlman, R.L. Co., 6730 Olive St. Rd., St. Louis 5, Mo.
Pohlman Foundry Co., Inc., 205 Baitz Ave., Buffalo 6, N.Y.
Polacoat, Inc., 9752 Conklin Rd., Cincinnati 42, Ohio
Polar Ware Co., Lakeshore Rd., Sheboygan, Wis.
Pollock, Robert Co., 123 S Maryland Ave., Glendale, Calif.
Polo Plastics Co., 1718 N 1st St., Milwaukee 12, Wis.
Poly Resins, 11661 Wicks St., Sun Valley, Calif.
Polycast Corp., 69 Southfield Ave., Stamford, Conn.
Polyform Plastics Corp., 24 University Pl., New York 3, N.Y.
Polygon Plastic Co., Walkerton, Ind.
Polymer Chemical Co., 5920 Carthage Ave., Cincinnati 12, Ohio
Polymer Corp., 2120 Fairmont Ave., Reading, Pa.
National Polymer Products, Inc. Sub. (Ad p 230)
125 N 4th St., Reading, Pa.
Polymer Corp. of Pennsylvania Sub. (Ad p 230)
2140 Fairmont Ave., Reading, Pa.
Polymer Industries Inc., Springdale, Conn.
Polyphase Machine Co., 43-22 50th St., Woodside 77, N.Y.
Polyplastic Products, Inc., 24th Ave., Paterson, N.J.
Poor & Co., 80 E Jackson Blvd., Chicago, Ill.
Canton Forge & Axle Works, 2025 Dueber Ave., SW, Canton 6, Ohio
Promat Div., 851 S Market St., Waukegan, Ill.
Porcelain Enamel Finishers, 3221 W 30th St., Chicago 23, Ill.
Porcelain Products, Inc., 224 N Patterson, Carey, Ohio
Portable Electric Tools, Inc., Admiral Die Castings Div., 250 W 83rd St., Chicago 20, Ill.
Porter, H.K. Inc., 74 Foley, Somerville 43, Mass.
Porter, H.K. Co., Inc., Alcoa Bldg., Pittsburgh 19, Pa.
Connors Steel Div., 5000 Powell Ave., Birmingham 12, Ala.
Forge & Fittings Div., 3270 E 79th St., Cleveland 4, Ohio
Refractories Div., 250 1st National Bank Bldg., Pittsburgh 22, Pa.
Riverside-Alloy Metal Div. (Ad p 171)
1 Pavillion Ave., Riverside, N.J.
Thermoid Div., Tacony & Comly Sts., Philadelphia 24, Pa.
Vulcan-Kidd Steel Div., Aliquippa, Pa.
Porter, William Co., 1007 Santa Fe Ave., Los Angeles 21, Calif.
Portland Co., 58 Fore St., Portland, Me.
Portland Iron Works, 1335 NW Northrup St., Portland 9, Ore.
Posey Iron Works, Inc., 580 S Prince St., Lancaster, Pa.
Potts, C. & G. & Co., 816 Washington Ave., Indianapolis, Ind.
Powder Metals Products Co., 500 St. Marys St., St. Marys, Pa.
Powdercraft Corp., 746 Hayne St., Spartanburg, S. C.
Powell Pressed Steel Co., Hubbard, Ohio
Pratt & Lambert, Inc., 75 Tonawanda St., Buffalo 7, N.Y.
Pratt, William E. Mfg. Co., 155 N Wacker Dr., Chicago, Ill.
Precision Castparts Corp., 4600 SE Harney Dr., Portland 6, Ore.
Precision Extrusions, Inc., 132 S Addison St., Bensenville, Ill.
Precision Founders, Inc., 414 Hester St., San Leandro, Calif.
Precision Machine Co., 1110 E 22nd St., Indianapolis 2, Ind.
Precision Metal Products Co., P.O. Box 129, Ellwood City, Pa.
Precision Metal Spinning Co., 9861 Dixie Hwy., Clarkston, Mich.
Precision Metalsmiths, Inc., 1081 E 200 St., Cleveland 17, Ohio
Precision Paper Tube Co., 2035 W Charleston St., Chicago 47, Ill.
Precision Piece Parts, Inc., 712 S Logan St., Mishawaka, Ind.
Precision Plastics Co., 4655 Stenton Ave., Philadelphia 44, Pa.
Precision Rubber Products Corp., 3110 Oakridge Dr., Dayton 7, Ohio
Precision Screw Products Co., Inc., 4764 Valley Blvd., Los Angeles 32, Calif.
Precision Tube Co., Inc., Church Rd. & Wissahickon Ave., North Wales, Pa.
Premier Metal Works, Inc., 1616 S Clinton St., Chicago 16, Ill.
Premier Thermo Plastics Co., Jeffersontown, Ky.
Prescott Co., 1610 15th St., Menominee, Mich.
Presmet Corp., 112 Harding St., Worcester 4, Mass.
Pressed Steel Co., Wilkes Barre, Pa.
Pressed Steel Tank Co., 1493 S 66th St. Milwaukee 14, Wis.
Presstite-Keystone Engineering Products Co., 3738 Chouteau Ave., St Louis, Mo.
Pressure Castings, Inc., 21500 St. Clair Ave., Cleveland 19, Ohio
Presswork, Inc., 9100 Roselawn Ave., Detroit 4, Mich.

Presto Plastic Products Co., Inc., 11 E 26th St., New York 10, N.Y.
Prestole Corp., 1345 Miami St., Toledo 5, Ohio
Prince Rubber Co., Inc., 1675 Niagara St., Buffalo 7, N.Y.
Production Die Casting Co., P.O. Box 9456, Houston 11, Tex.
Progressive Service Co., 2745 Locust St., St. Louis 3, Mo.
Protective Treatments, Inc., 420 Dellrose Ave., Dayton, Ohio
Puget Sound Plywood, Inc., 230 E. F St., Tacoma 2, Wash.
Pure Carbon Co., Inc., 441 Hall Ave., St. Marys, Pa.
Puritan Co., Inc., Beach & Lyell Aves., Rochester, N.Y.
Pusey & Jones Corp., Front & Poplar Sts., Wilmington 9, Del.
Pyramid Industries, Inc., 1422 Irwin Dr., Erie, Pa.
Pyramid Mouldings, Inc., 5353 W Armstrong Ave., Chicago 46, Ill.
Pyramid Plastics, Inc., 556 W Polk St., Chicago 7, Ill.
Pyro Plastics Corp., Pyro Park, Union, N.J.
Pyron Corp. (Ad p 418)
  Box E, LaSalle Sta., Niagara Falls, N.Y.
Pyrosil, Inc., P.O. Box 206, Cuyahoga Falls, Ohio

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Quaker Alloy Casting Co., Myerstown, Pa.
Quaker City Felt Co., 1734-36 Ludlow St., Philadelphia, Pa.
Quaker State Metals Co., P.O. Box 1167, Lancaster, Pa.
Quality Electric Steel Castings, Inc., P.O. Box 9382, Houston 11, Tex.
Queen Products Co., Inc., 13th & Rowan Sts., Louisville 3, Ky.
  Albert Lea Foundry Div., 902-910 E Main, Albert Lea, Minn.
Quelcor, Inc., Front & Broomall Sts., Chester, Pa.
Quest, J.F. Foundry Co., 900 4th St., S, Minneapolis 15, Minn.
Quincy Steel Casting Co., 30 Fayette St., North Quincy 71, Mass.
Quinn-Berry Corp., 2609 W 12th St., Erie, Pa.

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Racine Screw Co., 1501 Clark St., Racine, Wis.
Radiant Color Co., 830 Isabella St., Oakland 7, Calif.
Raffi and Swanson, Inc., 100 Eames St., Wilmington, Mass.
Rainier Metal Products Co., 2412 W 71st St., Chicago 29, Ill.
Rand Rubber Co., 397 Sumner Ave., Brooklyn 16, N.Y.
Randolph Products Co., 18 12th St., Carlstadt, N.J.
Rangers Die Casting Co., 10828 S Alameda St., Lynwood, Calif.
Rankin Forge Co., 117 Fort Pitt Blvd., Pittsburgh 22, Pa.
Rasco-Veeder Co., 1600 S Dearborn St., Chicago 16, Ill.
Rathbone Corp., Park St., Palmer, Mass.
Rausch Mfg. Co., Inc., 750 Pelham Blvd., St. Paul 14, Minn.
Ravenswood Machine Corp., 3325 N Knox Ave., Chicago 41, Ill.
Raybestos-Manhattan, Inc., 61 Willett St., Passaic, N.J.
  Adhesives Div. (Ad p 455)
    P.O. Box 1021, Bridgeport 2, Conn.
  Plastic Products Div. (Ad p 256)
    P.O. Box 1021, Bridgeport 2, Conn.
  Raybestos Div., P.O. Box 1021, Bridgeport 2, Conn.
Reade Mfg. Co., Inc., 135 Hoboken Ave., Jersey City 2, N.J.
Reading Tube Corp., Empire State Bldg., 350 5th Ave., New York, N.Y.
Red Devil Mfg. Co., 1412 N Ogden Ave., Chicago 10, Ill.
Redmer Air Devices, Box 247, Guntersville, Ala.
Reduction and Refining Co., Kenilworth, N.J.
Reed Plastics Corp., 116 Gold St., Worcester 8, Mass.
Reed & Prince Mfg. Co., 1 Duncan Ave., Worcester 1, Mass.
Reese Metal Products Corp., 537 Howard Ave., Lancaster, Pa.
Reeves Bros., Inc., Vulcan Rubber Products Div., 1071 Ave. of Americas, New York, N.Y.
Refinery Castings Co., P.O. Box 5085, Dallas 22, Tex.
Reflin Co., 5730 Kearney Villa Rd., San Diego 11, Calif.
Refractory & Insulation Corp., 120 Wall St., New York 5, N.Y.
Refractory Specialties Co., 2200 Washington Ave., Philadelphia 46, Pa.
Regal Plastic Co., 2800 E 14th St., Kansas City 27, Mo.
Regal Ware, Inc., Kewashum, Wis.
Reichhold Chemicals, Inc., 525 N Broadway, White Plains, N.Y.
Reinhold Engineering & Plastics Co., 12827 E Imperial Hwy., Norwalk, Calif.
Reliable Screw Machine Products, 4433 W Rice St., Chicago 51, Ill.
Reliable Spring & Wire Forms Co., 3167 Fulton Rd., Cleveland 9, Ohio
Reliance Foundry Co., 500-526 E Front St., Cincinnati 2, Ohio
Reliance Plastic & Chemical Corp., 110 Kearney St., Paterson 2, N.J.
Reliance Steel Castings Co., 2818 Smallman St., Pittsburgh 22, Pa.
Remler Co., Ltd., 2101 Bryant St., San Francisco 10, Calif.
Ren Plastics, Inc., 5422 S Cedar Rd., Lansing 17, Mich.
Rensselaer Valve Co., Cohoes, N.Y.
Replac Corp., 2130 St. Clair Ave., Cleveland 17, Ohio
Republic Die Casting Co., 611 Talcott Ave. St. Louis 7, Mo.
Republic Lead Equipment Co., 7930 Jones Rd., Cleveland 5, Ohio
Republic Metals Co., Inc., 273 Green, Brooklyn 22, N.Y.
Republic Steel Corp. (Ad pp 82-83)
  Republic Bldg., Cleveland 1, Ohio
  Steel & Tubes Div., 224 E 131st St., Cleveland 8, Ohio
Resistoflex Corp., Woodland Rd., Roseland, N.J.
Resolite Corp., P.O. Box 366, Zelienople, Pa.
Revere Copper & Brass, Inc., 230 Park Ave., New York 17, N.Y.
  Foil Div., 196 Diamond St., Brooklyn 22, N.Y.
  Rome Mfg. Div., Mill St., Rome, N.Y.
Rex Corp., Hayward Rd., West Acton, Mass.
Rex Products Co., 1918 E 55th St., Cleveland 3, Ohio
Reynolds Aluminum Supply Co., 573 W Peachtree St., NE, Atlanta 3, Ga.
Reynolds Chemical Products Co. (Ad p 258)
  1200 N Main St., Ann Arbor, Mich.
Reynolds Metals Co., P.O. Box 2346-2H, Richmond 18, Va.
  Foil Div., Reynolds Metals Bldg., Richmond 18, Va.
Rezolin, Inc., 1051 18th St., Santa Monica, Calif.
Rhoads, J.E. & Sons, 2100 W 11th St., Wilmington, Del.
Rhode Island Tool Co. (Ad p 406)
  142 W River St., Providence 1, R.I.
Richardson Co., 2882 Lake St., Melrose Park, Ill.
Richmond Foundry & Mfg. Co., Inc., 1300 Hermitage Rd., Richmond 20, Va.
Richmond Mfg. Co., 312 N York St., Houston 3, Tex.
Richmond Mica Corp., 900 Jefferson Ave., Newport News, Va.
Ridge Foundry, 1554 Doolittle Dr., San Leandro, Calif.
Riegel Paper Co., 260 Madison Ave., New York 16, N.Y.
Rigidized Metals Corp. (Ad p 420)
  658 Ohio St., Buffalo 3, N.Y.
Rinshed-Mason Co., Milford at Epworth, Detroit, Mich.
River Smelting & Refining Co., 4195 Bradley Rd., Cleveland 1, Ohio
Riverside Foundry Co., N Front St., Wrightsville, Pa.
Riverside Foundry & Galvanizing Co., 508 Harrison St., Kalamazoo, Mich.
Riverside Plastics Corp., 220 Miller Rd., Hicksville, N.Y.
Robertson, H.H. Co., 2400 Farmer Bank Bldg., Pittsburgh, Pa.
Robertson Steel & Iron Co., 72 Elm St., Cincinnati 2, Ohio
Robot Devices, Inc., Main St., Buchanan, Va.
Rochester Novelty Works, Inc., 485 Hague St., Rochester 6, N.Y.
Rockford Bolt & Steel Co., 126 Mill St., Rockford, Ill.
Rockwell Mfg. Co., LFM Mfg. Co., Inc. Sub., Atchison, Kan.
Rockwell - Standard Corp., Bossert Stamping Div. (Ad p 412)
  1002 Oswego St., Utica 1, N.Y.
Roddis Plywood Corp., Marshfield, Wis.
Rode, Inc., R5 Green St., Woburn, Mass.
Rodney Hunt Machine Co., 46 Mill St., Orange, Mass.
Rodney Metals, Inc., 261 5th Ave., New York 16, N.Y.
Roebling's, John A. Sons Corp., 640 S Broad St., Trenton 2, N.J.
Rogers Corp., Rogers, Conn.
Rogers, V.F. Plastic Molding, 4320 Fox St., Denver 16, Colo.
Rohm & Haas Co. (Ad p 245)
  Washington Square, Philadelphia 5, Pa.
Rohnco, Inc., 116 Limestone, Bellevue, Peoria 5, Ill.
Rolinco, Inc., 116 Limestone, Bellevue, Peoria 5, Ill.
Roll Coater, Inc., Box 67, Pendleton, Ind.
Roll Formed Products Co. (Ad p 413)
  3752 Oakwood Ave., Youngstown, Ohio
Rolle Mfg. Corp., 3rd & Cannon St., Lansdale, Pa.
Rolled Alloys, Inc., 5309 Concord, Detroit 11, Mich.
Roller Reinforced Plastics, W 47th St., Box 192, Ashtabula, Ohio
Rolock, Inc., 1350 Kings Hwy., Fairfield, Conn.
Romar Plastics, Inc., 1311 E Main St., St. Charles, Ill.
Rome Strip Steel Co., Inc., 530 Henry St., Rome, N.Y.
Rome Turney Radiator Co., Rome, N.Y.
Rosan, Inc., 2901 W Coast Hwy., Newport Beach, Calif.
Rosco Laboratories, 29 Moore St., Brooklyn 6, N.Y.
Rose Iron Works, 1539 E 43rd St., Cleveland 3, Ohio
Rosedale Foundry & Machine Co., 1731 Prebel Ave., Pittsburgh 33, Pa.
Ross & Roberts, Inc., 1299 W Broad St., Stratford, Conn.
Ross-Meehan Foundries, 1601 Carter St., Chattanooga 1, Tenn.
Rostone Corp., Rd. 52 S, Lafayette, Ind.
Roth Rubber Co. (Ad p 261)
  1854 S 54th St., Chicago 50, Ill.
Roth Steel Products Co., 1335 E 171st St., Cleveland 10, Ohio
Rotometals, 980 Harrison St., San Francisco 7, Calif.
Rowland Products, Inc., Fairview Lane, Kensington, Conn.
Royce Aluminum Corp., 704 W Water St., Taunton, Mass.
Rubber & Asbestos Corp., 225 Belleville Ave., Bloomfield, N.J.
Rubber Corp. of America, New South Rd., Hicksville, L.I., N.Y.
Rubber & Plastics Compound Co., Inc., 10 Rockefeller Plaza, New York 20, N.Y.
Ruberoid Co., 500 5th Ave., New York 36, N.Y.
Ruby Chemical Co., 68-70 McDowell St., Columbus 16, Ohio
Rupert Diecasting Co., 1655 Cleveland Ave., Kansas City 27, Mo.
Russell, Burdsall & Ward Bolt & Nut Co., Midland Ave., Port Chester, N.Y.
Russell Mfg. Co., 400 E Main St., Middletown, Conn.
Russell Reinforced Plastics Corp., 521 W Hoffman Ave., Lindenhurst, N.Y.
Rust-Oleum Corp., 2425 Oakton St., Evanstown, Ill.
Rustproofing & Metal Finishing Corp., 75 Commercial Ave., Cambridge 42, Mass.
Ryerson, Joseph T. & Son, Inc., 16th & Rockwell Sts., Chicago 80, Ill.

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S & S Mfg. Co., 6139 Adams St., West New York, N.J.
Saginaw Bay Industries, Inc., 242 N Water St., Bay City, Mich.
Saginaw Bearing Co., 821 S Water St., Saginaw, Mich.
St. Clair Rubber Co., 440 E Jefferson Ave., Detroit 26, Mich.
St. Eloi Corp., 3509 Debolt Rd., Newtown Station, Cincinnati 44, Ohio
St. Joseph Lead Co., 250 Park Ave., New York 17, N.Y.
St. Louis Diecasting Corp., 4528 Oleatha Ave., St. Louis 16, Mo.
St. Louis Malleable Casting Co., 7701 N Conduit Ave., St. Louis, Mo.
St. Louis Steel Casting, Inc., 100 Mott St., St. Louis 15, Mo.
St. Marys Carbon Co., State Rd., St. Marys, Pa.

In contacting suppliers, please mention the Materials Selector

St. Marys Foundry Co., P.O. Box 248, St. Marys, Ohio

St. Pierre Chain Corp., 50 Frank St., Worcester 4, Mass.

St. Regis Paper Co., 150 E 42nd St., New York, N.Y.

Cambridge-Panelyte Molded Plastics Co. Div., Cambridge, Ohio

Chester Packaging Div., 684 Nepperhan Ave., Yonkers, N.Y.

Panelyte Div., 261 Madison Ave., New York 16, N.Y.

Sall Bros. Co., 2300 Kishwaukee St., Rockford, Ill.

Sall, George Metals Co., Inc., 2255 E Butler St., Philadelphia 37, Pa.

San Francisco Galvanizing Works, 1180 Harrison St., San Francisco 3, Calif.

San Francisco Iron Foundry, 260 Townsend St., San Francisco 7, Calif.

Sandusky Foundry & Machine Co. (Ad p 405)
W Market St., Sandusky, Ohio

Sandvik Steel, Inc. (Ad p 96)
1702 Nevins Rd., Fair Lawn, N.J.

Sandy Hill Iron & Brass Works, 27 Allen St., Hudson Falls, N.Y.

Sanford Plastics Corp., 521 Fifth Ave., New York 17, N.Y.

Santay Corp., 351 N Crawford Ave., Chicago 24, Ill.

Saramar Aluminum Co., 4021 Mahoning Ave., Youngstown 1, Ohio

Saran Lined Pipe Co., 2415 Burdette Ave., Ferndale 20, Mich.

Sargent & Greenleaf, Inc., 24 Seneca Ave., Rochester 21, N.Y.

Sauereisen Cements Co., 1045 N Canal St., Pittsburgh 15, Pa.

Savannah Machine and Foundry Co., Foundry Div., P.O. Box 590, Savannah, Ga.

Sawbrook Steel Castings Co., Shepherd & McWhorter Sts., Lockland, Cincinnati 15, Ohio

Sawhill Tubular Products, Inc., P.O. Box 11, Sharon, Pa.

Saxonburg Ceramics, Saxonburg, Pa.

Scaife Co., Anne St., Oakmont, Pa.

Schachner Leather & Belting Co., Charlotte Leather Belting Co. Div., P.O. Box 3205, Charlotte 3, N.C.

Schaefer-Goodnow Foundries, Inc., 2 36th St., Pittsburgh 1, Pa.

Schaefer-Hausner Corp., 527 Lexington Ave., New York 17, N.Y.

Schenectady Varnish Co., Inc., Congress St. & 9th Ave., Schenectady 3, N.Y.

Schilling Bronze Co., 202-216 E North St., Rome 2, N.Y.

Schlueter Mfg. Co., 4616 N Broadway, St. Louis 7, Mo.

Schmeller Aluminum Foundry Co., 3300 E 87th St., Cleveland 27, Ohio

Schneider, Bowman Co., Inc., 1612 Van Dyke St., Philadelphia 24, Pa.

Schultz Die Casting Co., 1810 Clinton St., Toledo 7, Ohio

Schumann, I. & Co., 4391 Bradley Rd., P.O. Box 2219, Cleveland 9, Ohio

Schwab Plastics Corp., 17310 Northlawn, Detroit, Mich.

Schwartz Chemical Co., Inc., 50-01 2nd St., Long Island City, N.Y.

Schwarzkopf Development Corp., 595 Madison Ave., New York 22, N.Y.

Scott Paper Co., Foam Div., Delaware & Broomall, Chester, Pa.

Scottdale Ozone Co., Crescent St., Scottdale, Pa.

Scovill Mfg. Co., Mill Products Div. (Ad pp 165-166)
99 Mill St., Waterbury 20, Conn.

Scranton Plastic Laminating Corp., 3216-18 Pittston Ave., Scranton 5, Pa.

Screw Products Co., 2909 Logan St., Lansing 17, Mich.

Scudder, E.J. Foundry & Machine Co. Canal & Pearl Sts., Trenton 9, N.J.

Scullin Steel Co., 6700 Manchester Ave., St. Louis 10, Mo.

Seal-Peel, Inc., 755 Stephenson Hwy., Royal Oak 3, Mich.

Sealube Co., 14 Valley St., Wakefield, Mass.

Sealview Plastics, Inc., 1010 Ford St., West Conshohocken, Pa.

Seaman Products, 120 W Providencia Ave., Burbank, Calif.

Seamless Rubber Co., 464 Congress St., New Haven 3, Conn.

Seaporcel Metals, Inc., 28-20 Borden Ave., Long Island City, N.Y.

Seattle Boiler Works, Inc., 5237 E Marginal Way, Seattle, Wash.

Security Cos., 20096 James Couzens, Detroit 38, Mich.

Security Sash & Screen Co., 20096 James Couzens Hwy., Detroit 35, Mich.

Seiberling Rubber Co., Plastics Div., Newcomerstown, Ohio

Selma Foundry & Machine Co., P.O. Box 662, Selma, Ala.

Sel-Rex Corp. (Ad p 331)
75 River Rd., Nutley 10, N.J.

Seltzer, George H. & Co., Ridley & B & O RR, P.O. Box 66, Folsom, Pa.

Semon Bache & Co., 636 Greenwich St., New York 14, N.Y.

Seneca Wire & Mfg. Co., Fostoria, Ohio

Sequoia Metalcraft Co., Inc., 1001 Washington St., San Carlos, Calif.

Serrick Corp., Defiance, Ohio

Acme Machine Products Div., 1300 Batavia St., Muncie, Ind.

John Lees Div., 1300 Batavia St., Muncie, Ind.

Screw Machine Products Div., 731-22 Perry, Defiance, Ohio

Service Steel Co., 1435 Franklin St., Detroit 7, Mich.

Servwell Products Co., 6541 Euclid Ave., Cleveland 3, Ohio

Set Screw & Mfg. Co. (Ad p 456)
149 Main St., Bartlett, Ill.

Sewell Mfg. Co., 1019 E 10 Mile Rd., Hazel Park, Mich.

Seymour Mfg. Co. (Ad p 154)
15 Franklin St., Seymour, Conn.

Shakopee Foundry Co., Shakopee, Minn.

Shamban, W.S & Co., 11617 W Jefferson Blvd., Culver City, Calif.

Shank Metal Products Co., 347 Madison Ave., New York 17, N.Y.

Sharon Steel Corp. (Ad p 86)
Sharon, Pa.

Brainard Steel Div., Griswold St., Warren, Ohio

Sharpsville Steel Fabricators, Inc., 6th & Main Sts., Sharpsville, Pa.

Shaw Insulator Co., 160 Colt St., Irvington 11, N.J.

Shawinigan Resins Corp., 644 Monsanto Ave., Springfield 1, Mass.

Shaw-Kendall Engineering Co., 120 S Superior St., P.O. Box 1736, Toledo 3, Ohio

Sheffield Foundry Co., 2070 Clybourn Ave., Chicago 14, Ill.

Shelby Instrument Co., 1701 Magnolia Ave., Long Beach, Calif.

Shelby Mfg. Co., E Russel Rd., Sidney, Ohio

Shell Chemical Corp., 50 W 50th St., New York 20, N.Y.

Sheller Mfg. Corp., 8-159 General Motors Bldg., Detroit 2, Mich.

Dryden Rubber Div., 1014 S Kildare Ave., Chicago 24, Ill.

Shenango Furnace Co., Centrifugally Cast Products Div., Dover, Ohio

Shenango Refractories, P.O. Box 120, New Castle, Pa.

Sherman & Reilly, Inc., 1st & Broad Sts., Chattanooga, Tenn.

Sherwin-Williams Co., 101 Prospect Ave., NW, Cleveland 1, Ohio

Shieldalloy Corp., West Blvd., New Field, N.J.

Shingle Leather Co., 1300 Walnut St., Camden 3, N.J.

Shoe Form Co., Inc., Aurelius Ave., Auburn, N.Y.

Shriver, T. & Co., Inc., 390 Hamilton St., Harrison, N.J.

Shull Bros. Glass Co., 509 N 6th St., Millville, N.J.

Shur-Lok Corp., 879 S East St., Anaheim, Calif.

Sibley Machine & Foundry Corp., 206 E Tutt St., South Bend 23, Ind.

Sierra Electric Corp., 15100 S Figueroa St., Gardena, Calif.

Sierra Engineering Co., 123 E Montecito, Sierra Madre, Calif.

Sifco Metachemical, Inc., 935 E 63rd St., Cleveland 3, Ohio

Sillcocks Miller Co., 10 W Parker Ave., Maplewood, N.J.

Simmons Fastener Corp. (Ad p 455)
N Broadway, Albany 1, N.Y.

Simon Products Co., 3211 W Grand St., Chicago 51, Ill.

Simonds Saw and Steel Co., 470 Main St., Fitchburg, Mass.

Simonsen Metal Products Co., 4444 W Chicago, Chicago 51, Ill.

Simpson Timber Co., 1010 White Bldg., Seattle, Wash.

Sinclair Co., 60 Appleton St., Holyoke, Mass.

Sinko Mfg. & Tool Co., 7310 W Wilson Ave., Chicago 31, Ill.

Sintercast Corp. of America, 134 Woodworth Ave., Yonkers 2, N.Y.

Sintered Metals, Inc., 3390 Washington St., Jamaica Plain 30, Mass.

Sioux City Foundry & Boiler Co., E 8th & Division Sts., Sioux City 2, Iowa

Sipe Metals Corp., 1720 N Elston Ave., Chicago 22, Ill.

Sivyer Steel Casting Co., 43rd & Mitchell Ave., Milwaukee 14, Wis.

Skookum Co., Inc., 8504 W Crawford St., Portland 3, Ore.

Skyline Industries, Titusville 1, Pa.

Small Tube Products, Inc., Main St., Waterbury, Conn.

Smith, A.O. Corp., 3533 N 27th St., Milwaukee 1, Wis.

Smith, A.P. Mfg. Co., 500 N Arlington Ave., East Orange, N.J.

Smith, Nowery J. Bolt & Supply Co., P.O Box 7398, Houston 8, Tex.

Smith Chemical & Color Co., Inc., 55 John St., Brooklyn 1, N.Y.

Smith & Winchester Mfg. Co., South Windham, Conn.

Smith-Armstrong Forge, Inc., 1209 Marquette Rd., Cleveland 14, Ohio

Smithers Tool & Machine Products, Inc., 645 Broadway, Red Hook, N.Y.

Smith-Moon Steel Co., Inc., Courier Bldg., Winfield, Kan.

Smith-Victor Corp., Griffith, Ind.

Smoot-Holman Co., 321 N Eucalyptus Ave., Inglewood, Calif.

Snyder Mfg. Co., Inc., 1458 5th St. NW, New Philadelphia, Ohio

Snyder, M.L. & Son, Inc., Jasper & York Sts., Philadelphia 15, Pa.

Solar Aircraft Co., 2200 Pacific Hwy., San Diego 12, Calif.

Solar Steel Corp., Union Commerce Bldg., Cleveland, Ohio

Solon Foundry, Inc.. 6370 SOM Center Rd., Solon, Ohio

Somerset Foundry & Machine Co., 809-831 Edgewood Ave., Somerset, Pa.

Somers Brass Co., Inc. (Ad p 150)
94 Baldwin Ave., Waterbury 20, Conn.

Sommer Metalcraft Corp., 315 Poston Dr., Crawfordsville, Ind.

Sonith Foundries, Food Machinery Corp., 50 Shelby St., Indianapolis 6, Ind.

Sonken-Galamba Corp., 2nd & Riverview, Kansas City 18, Kan.

Sorbo-Cast Corp., New Brunswick, N.J.

Sorbo-Mat Process Engineers, 106 S Hanley St., St. Louis 5, Mo.

South Chester Corp., Southco Div., Lester, Pa.

South River Metal Products Co., Inc., 377 Turnpike, South River, N.J.

Southern Adhesives Corp., 1501 W Moore St., Richmond, Va.

Southern Aluminum Finishing Co., Inc., 1581 Huber St., NW, Atlanta 18, Ga.

Southern Asbestos Co., 1000 Seaboard Rd., Charlotte, N.C.

Southern Belting & Transmission Co., P.O. Box 4296, Atlanta 2, Ga.

Southern Car & Mfg. Co., Inc., 1831 29th Ave. N, Birmingham, Ala.

Southern Extrusions, Inc., N Washington St., Magnolia, Ark.

Southern Fabricating Co., Inc., 818 20th St., Sheffield, Ala.

Southern Galvanizing Co., 1620 Bush St , Baltimore 30, Md.

Southern Metal Products Co., 4444 N Miro St., New Orleans 17, La.

Southern Plastics Co., 408 Pendelton St., Columbia, S.C.

Southern Screw Co., P.O. Box 1360, Statesville, N.C.

Southwestern Plastic Pipe Co., P.O. Box 117, Mineral Wells, Tex.

Southwestern Porcelain Steel Corp., P.O. Box 607, Sand Springs, Okla.

Spaulding Fibre Co., Inc. (Ad p 251)
310 Wheeler St., Tonawanda, N.Y.

Special Screw Products Co., 100 Northfield Rd., Bedford, Ohio

Specialty Resins Co., 2801 Lynwood Rd., Lynwood, Calif.

Speer Carbon Co., St. Marys, Pa.

Spencer Chemical Co., Dwight Bldg., 1004 Baltimore Ave., Kansas City 5, Mo.

Spencer Nahm Co., 765 1st Ave., San Leandro, Calif.

Spencer Rubber Co., Main & Chapel Sts., Manchester, Conn.

Spencer's Sons, I.S. Inc., 20 Fair St., Guilford, Conn.

Spincraft, Inc., 4122 W State St., Milwaukee 8, Wis.

Spiral-Glas Pipe Co., P.O. Box 1951, Old Bridge, N.J.

Spraylat Corp. (Ad p 328)
1 Park Ave., New York 16, N.Y.

Spring City Foundry Co., Hall & Main Sts., Spring City, Pa.

Spring Packing Corp., 332 S Michigan Ave., Chicago 4, Ill.

Springer's Foundry Co., Inc., 201 S 1st St., Terre Haute, Ind.

Springfield Foundry Co., 295 Pasco Rd., Indian Orchard, Mass.

Spruce Pine Mica Co., Inc., P.O. Box 456, Spruce Pine, N.C.

Spuck Iron & Foundry Co., 3145 N 14th St., St. Louis 7, Mo.

Stacey Mfg. Co., Township Ave., & Big Four RR, Cincinnati 16, Ohio

Stackpole Carbon Co. (Ad p 296)
St Marys, Pa.

Stainless Foundry & Engineering, Inc., 5132 N 35th St., Milwaukee 9, Wis.

Stainless Metals, Inc., 19-42 42nd St., Long Island City 1, N.Y.

Stalwart Rubber Co., 160 Northfield Rd., Bedford, Ohio

Stamford Metal Specialty Co., Inc., 429 W Broadway, New York 12, N.Y.

- Stamford Rolling Mills Co., Inc., Springdale, Conn.
- Standard Asbestos Mfg. Co., 860 W Evergreen Ave., Chicago 22, Ill.
- Standard Casting Corp., 4400 W Cormak Rd., Chicago 23, Ill.
- Standard Felt Co., 24-115 S Palm Ave., Alhambra, Calif.
- Standard Forge & Axle Co., Inc., P.O. Box 309, Montgomery 1, Ala.
- Standard Foundry Co., Southgate & Armory Sts., Worcester 10, Mass.
- Standard Insulation Co., Plastics Div., 74 Paterson Ave., East Rutherford, N.J.
- Standard Locknut & Lockwasher Inc., 2250-56 Valley Ave., Indianapolis 18, Ind.
- Standard Magnesium Corp., 7500 E 41st St., Tulsa, Okla.
- Standard Metals Corp., 262 Broad St., North Attleboro Mass.
- Standard Nut & Bolt Co., Abbott St., Valley Falls, R.I.
- Standard Packaging Corp., Johnston Foil Div., 6106 S Broadway, St. Louis 11, Mo.
- Standard Plastics Co., 62 Water St., Attleboro, Mass.
- Standard Pressed Steel Co., Box 888, Jenkintown, Pa.
- Standard Products Co., 316 Fisher Bldg., Detroit, Mich.
- Standard Screw Co., Wilson, Conn.
  - Chicago Screw Co., 2701 Washington Blvd., Bellwood, Ill.
  - Hartford Machine Screw Co., P.O. Box 1440, Hartford 2, Conn.
  - Western Automatic Machine Screw Co., 377 Woodland Ave., Elyria, Ohio
- Standard Screw Products Co., 506 S Palm Ave., Alhambra, Calif.
- Standard Stamping & Perforating Co., 3129 W 49th Place, Chicago 32, Ill.
- Standard Steel Sections, Inc., 608 E 133rd St., New York, N.Y.
- Standard Tube Co., 24400 Plymouth Rd., Detroit 39, Mich.
- Standard Washer & Mat, Inc., 155 Adams St., Manchester, Conn.
- Stanley Chemical Co., Berlin St., East Berlin, Conn.
- Stanley Works, Stanley Industrial Sales Div., 195 Lake St., New Britain, Conn.
- Stanwood Corp., 4819 Cortland, Chicago 39, Ill.
- Star Expansion Industries Corp., Pleasant Hill Rd., Mountainville, N.J.
- Star Heel Plate Co., Inc., 12 Thornton St., Newark 5, N.J.
- Star Porcelain Co., Muirhead Ave., Trenton, N.J.
- Star Stainless Screw Co., 194 Union Ave., Totowa, N.J.
- Star Stamping Co., 1303 M-139, Benton Harbor, Mich.
- Star Wire Screen & Iron Works Inc., 2515 San Fernando Rd., Los Angeles 65, Calif.
- Star Woolen Co., Cohoes, N.Y.
- State Foundry & Machine Co., Cedar Grove, Wis.
- Staver Co., Inc., 49 N Saxon Ave., Bay Shore, N.Y.
- Stearns-Roger Mfg. Co., 660 Bannock St., Denver, Cole.
- Steel Fabricators Co., 1252-B Spruce St., Cleveland 13, Ohio
- Steel Heddle Mfg. Co., 2100 Walleghemy Ave., Philadelphia 32, Pa.
- Steel Improvement and Forge Co., 970 E 64th St., Cleveland, Ohio
- Steel Industries, Inc., 907 Louise Ave., Crawfordsville, Ind.
- Steel Protection & Chemical Co., Mooresville, Ind.
- Steel Shot Producers, Inc., 4389 Harrison St., Pittsburgh 1, Pa.
- Steel, R. & Sons, Inc., 42-21 9th St., Long Island City 1, N.Y.
- Steelcote Mfg. Co., 3418 Gratiot St., St. Louis 3, Mo.
- Steinen, William Mfg. Co., 43 Bruen St., Newark 5, N.J.
- Stella Products Corp., 66 Okner Pky., Livingston, N.J.
- Stenman, Bror F., West St., Auburn, Mass.
- Sterling Aluminum Products, Inc., 2600 N 3rd St., St. Charles, Mo.
- Sterling Bolt Co., 363 W Erie St., Chicago 6, Ill.
- Sterling Brass Foundry, Inc., 1640 Sterling Ave., Elkhart, Ind.
- Sterling Die Casting Co., 743 39th St., Brooklyn 32, N.Y.
- Sterling Foundry Co., 8 Wallace St., Sterling, Ill.
- Sterling Models, Belford Ave. & Wister, Philadelphia, Pa.
- Sterling Molders, Inc., 277 Military Rd., Buffalo 7, N.Y.
- Sterrit-Thomas Foundry Co., 32nd & Smallman St., Pittsburgh 1, Pa.
- Stevens, Frederic B., Inc., 1800 18th St., Detroit, Mich.
- Stevens, J.P. & Co., Inc., 1460 Broadway, New York 36, N.Y.
- Steward, D.M. Mfg. Co., E 36th St., Chattanooga, Tenn.
- Stewart-Warner Corp., Stewart Die Casting Div., 4535 W Fullerton Ave., Chicago 30, Ill.
- Stillman Rubber Co., 5811 Marilyn Ave., Culver City, Calif.
- Stillman White Foundry Co., Inc., 42 Dodge St., Providence, R.I.
- Stimpson, Edwin B. Co., Inc., 70 Franklin Ave., Brooklyn 5, N.Y.
- Stirrup Metal Products Corp., 215 Emmet St., Newark 5, N.J.
- Stockwell Rubber Co., Inc., 1117 Shackamaxon St., Philadelphia 25, Pa.
- Stone Straw Corp., Stone Paper Tube Div., 900 Franklin St., NE, Washington 17, D.C.
- Stoody Co., Whittier, Calif.
- Stover Steel Tank & Mfg. Co., 100 S Hancock Ave., Freeport, Ill.
- Stowe-Woodward, Inc., 181 Oak St., Newton 64, Mass.
- Stranahan Foil Co., Inc., 100 Wesley St., South Hackensack, N.J.
- Strick Plastics Co., Perkasie, Pa.
- Strong Steel Foundry Co., 33 Norris St., Buffalo 7, N.Y.
- **Structural Fibers, Inc. (Ad p 398)**
  5th Ave., Chardon, Ohio
- Struthers Wells Corp., 30 Rockefeller Plaza, New York 20, N.Y.
- Stuart Foundry Co., 138 S Junction St., Detroit, Mich.
- Stulz-Sickles Co., 929-939 Julia St., Elizabeth, N.J.
- Subax, Inc., Fairmount Plant, Hackensack, N.J.
- Sun Chemical Corp., 10th St. & 44th Ave., Long Island City 1, N.Y.
  - Electro Chemical Corp., 113 E Centre St., Nutley 10, N.J.
  - Horn, A.C. Co., Inc., 750 3rd Ave., New York 17, N.Y.
- Sun Rubber Co., 366 Fairview Ave., Barberton, Ohio
- Sun Steel Co., Special Products Div., 1700 W 74th Pl., Chicago 36, Ill.
- Sun Tube Corp., 181 Long Ave., Hillside, N.J.
- Sunlite Plastics, Inc., 1512 W Pierce St., Milwaukee, Wis.
- Superb Light Alloys, Inc., Allen Blvd., Farmingdale, N.Y.
- **Superior Carbon Products, Inc. (Ad p 416)**
  9115 George Ave., Cleveland 5, Ohio
- Superior Die Casting Co., 1001 London Rd., Cleveland 10, Ohio
- Superior Drawn Steel Co., Beaver Ave., Monaca, Pa.
- Superior Foundry, Inc., 3542 E 71st St., Cleveland 5, Ohio
- Superior Industries, Inc., 3786 Oakwood Ave., Youngstown 9, Ohio
- Superior Mfg. Co., 13th & Rockland Sts., Philadelphia 41, Pa.
- Superior Plastics, Inc., 426 N Oakley Blvd., Chicago 12, Ill
- Superior Plating, Inc., 1064 10th Ave. SE, Minneapolis, Minn.
- Superior Spinning & Stamping Co., 4057-63 Fitch Rd., Toledo 13, Ohio
- Superior Steel Corp., Carnegie, Pa.
- Superior Steel & Malleable Castings Co., Benton Harbor, Mich.
- **Superior Tube Co. (Ad p 421)**
  Box 191, Norristown, Pa.
- Superior-Pacific Galvanizing Co., 1711 E 61st St., Los Angeles 1, Calif.
- Supreme Industrial Products Co., 367 N Karlov Ave., Chicago 24, Ill.
- Surprenant Mfg. Co., 199 Washington St., Boston 8, Mass.
- Swan Rubber Co., 436 E Mansfield St., Bucyrus, Ohio
- Swayne-Robinson & Co., 210 Main St., Richmond, Ind.
- Swedish Crucible Steel Co., 8801 Conant Ave., Detroit 11, Mich.
- Swedlow Inc., 6986 Bandini Blvd., Los Angeles, Calif.
- Swedlow Plastics Corp., 394 N Meridian Rd., Youngstown, Ohio
- Swepco Tube Corp., 1 Clifton Blvd., Clifton, N.J.
- Swett, A.L. Iron Works, 172 Glenwood Ave., Medina, N.Y.
- Sylvan Plastics Inc., 1617 Pennsylvania Ave., Philadelphia 3, Pa.
- Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N.Y.
  - Chemical & Metallurgical Div., Towanda, Pa.
  - **Parts Div. (Ad p 417)**
    Warren, Pa.
- Sylvester & Co., 17706 Miles Ave., Cleveland 28, Ohio
- Symington-Gould Corp., Depew, N.Y.
- Synco Resins, Inc., Henry St., Bethel, Conn.
- Synthane Corp., River Rd., Oaks, Pa.

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- Tallman-McCluskey Fabrics Co., 230 E Monroe, Kirkwood 22, Mo.
- Taylor & Co., Inc., 680 Morgan Ave., Brooklyn 22, N.Y.
- Taylor & Boggis Foundry, 1290 E 53rd St., Cleveland, Ohio
- **Taylor Fibre Co. (Ad p 227)**
  Box 471, Norristown, Pa.
- Taylor Forge & Pipe Works, P.O. Box 485, Chicago 90, Ill.
- Techalloy Co., Inc., Rte. 113, Rahns 5, Pa.
- Technic, Inc., 39 Snow St., Providence 3, R.I.
- Technical Ply-Woods Sales, 6756 Crandon Ave., Chicago 49, Ill.
- Technical Specialties Co., 415 Concord Ave., New York 55, N.Y.
- Technical Tape Corp., 240 North Ave., New Rochelle, N.Y.
- Teiner, Roland Co., Inc., 134 Tremont St., Everett 49, Mass.
- Temco, Inc., 4101 Charlotte Ave., Nashville, Tenn.
- Terre Haute Bronze & Brass Foundry, 1114 Sycamore St., Terre Haute, Ind.
- Terre Haute Malleable & Mfg. Corp., 2030 N 19th St., Terre Haute, Ind.
- Testor Chemical Co., 600 Buckbee, Rockford, Ill.
- Texas Aluminum Co., Inc., 512 Mercantile Securities Bldg., Dallas, Tex.
- Texas Foundries, Inc., P.O. Box 180, Lufkin, Tex.
- Texas Glass Fiber Corp., 147 Island Grove Rd., Grandview, Tex.
- Texas Plastic Development Corp., 2120 Post Oak Rd., Houston, Tex.
- Texas Steel Co., 3901 Hemphill St., Fort Worth 9, Tex.
- **Texas-U.S. Chemical Co. (Ad pp 233-238)**
  260 Madison Ave., New York, N.Y.
- Textile Shield Co., Inc., 1 Groton St., Lawrence, Mass.
- Textron, Inc., 50 S Main, Providence, R.I.
  - Burkart, F. Mfg. Co., 4900 N 2nd St., St. Louis 7, Mo.
  - Campbell, Wyant & Cannon Foundry Co., Henry St., Muskegon, Mich.
- Textron Metals Co., 39 James St., Girard, Ohio
- Thalco, 765 S Harvard Blvd., Los Angeles, Calif.
- Thatcher Glass Mfg. Co., Inc., McKee Div., Bullitt Ave., Jeannette, Pa.
- Thermaflow Chemical Corp., Box 115, Tunkhannock, Pa.
- Thermal American Fused Quartz Co., 18 Salem St., Dover, N.J.
- Thermal Refractories Corp., 4501 Dell Ave., North Bergen, N.J.
- Thermo Materials, Inc., 4040 Campbell Ave., Menlo Park, Calif.
- Thinsheet Metals Co., 271-TR Railroad Hill St., Waterbury 20, Conn.
- Thiokol Chemical Corp., 780 N Clinton Ave., Trenton 7, N.J.
- Thombert, Inc., 316 E 7th St., N, Newton, Iowa
- Thompson and Co., 1085 Allegheny Ave., Oakmont, Pa.
- **Thompson, H. I. Fiber Glass Co. (Ad p 263)**
  1733 Cordova St., Los Angeles 7, Calif.
- Thompson Industries, Inc., Manhasset, N.Y.
- Thompson Pipe & Steel Co., 3001 Larimer St., P.O. Box 2852, Denver 1, Colo.
- Thompson Products, Inc., 23555 Euclid Ave., Cleveland 17, Ohio
  - Light Metals Div., 2269 Ashland Rd., Cleveland, Ohio
  - Kolcast Industries Div., P.O. Box 250, Minerva, Ohio
  - Valve Div., 1455 E 185th St., Cleveland 10, Ohio
- Thompson, K.W. Tool Co., 20 Dexton Ave., New Hyde Park, N.Y.
- Thompson Wire Co., 41 Mildred Ave., Boston 26, Mass.
- Thompson-Bremer & Co., 228 N La Salle St., Chicago 1, Ill.
- Thomson, Judson L. Mfg. Co., Sawyer Rd., Waltham, Mass.
- Thys Co., 6900 Folsom Blvd., Sacramento 19, Calif.
- Tiarco Corp., Box 766, Clark, N.J.
- Tickle, Arthur Engineering Works, Inc., 21 Delevan St., Brooklyn 31, N.Y.
- Timber Products Co., P.O. Box 1032, Medford, Ore.
- Timken Roller Bearing Co., Steel & Tube Div., 1835 Dueber Ave., SW Canton 6, Ohio

Tingley Rubber Corp., 903 Ross St., Rahway, N.J.
Tinnerman Products, Inc., Dept. 16, P.O. Box 6688, Cleveland 1, Ohio
Titan Metal Mfg. Co. (Ad p 388)
Bellefonte, Pa.
Titanium Metals Corp. of America, 233 Broadway, New York 7, N.Y.
Titchener, E. H. & Co., 67 Clinton St., Binghamton, N.Y.
Toepfer & Sons, Inc., 6667 N Teutonia Ave., Milwaukee 9, Wis.
Toledo Industrial Rubber Co., 2242 Smead Ave., Toledo 6, Ohio
Toledo Stamping & Mfg. Co., 99 Fearing Blvd., Toledo 7, Ohio
Tompkins Products, 1040 W Grand Blvd., Detroit 8, Mich.
Tool & Mfg. Co., Inc., P.O. Box 10344, Pittsburgh 34, Pa.
Topeka Foundry & Iron Works Co., Inc., 300-324 Jackson St., Topeka, Kan.
Torngren, C.W. Co., Inc., 236 Pearl St., Somerville 45, Mass.
Torrington Co., 59 Field St., Torrington, Conn.
Specialties Div., Torrington, Conn.
Tousey Varnish Co., 520 W 25th St., Chicago 16, Ill.
Tower Grove Foundry, 4438 Hunt Ave., St. Louis 10, Mo.
Townsend Co., Fasteners Div., P.O. Box 71, Ellwood City, Pa.
Toyad Co., Plant Blvd., Latrobe, Pa.
Trane Co., 206 Cameron Ave., LaCrosse, Wis.
Transue & Williams Steel Forging Corp., 562 W Ely St., Alliance, Ohio
Trenton Brass Co., 621 Prospect St., Trenton, N.J.
Triangle Conduit & Cable Co., Inc., 6900 Jersey Ave., New Brunswick, N.J.
Triangle Stamping Co., 5101 Carnegie Ave., Cleveland 3, Ohio
Trigon Specialties Corp., 1005 S Lafayette Blvd., South Bend 18, Ind.
Trim Alloys, Inc., 30-40 W 3rd St., Boston 27, Mass.
Tri-Point Mfg. & Developing Co., 171 I. U. Willets Rd., Alberton, L.I., N.Y.
Tri-State Plastic Molding Co., 505 4th St., Henderson, Ky.
Trojan Steel Co., P.O. Box 2426, Charleston 29, W. Va.
Trostel, Albert Packings, Ltd., Lake Geneva, Wis.
Troy Blanket Mills (Ad p 286)
200 Madison Ave., New York, N.Y.
Trucke Leather Co., Peabody, Mass.
True Alloys, Inc., 284 S Summit St., Detroit 9, Mich.
Tube Distributors Co., Inc., 1415 Kellum Pl., Garden City, N.Y.
Tube Methods, Inc., Depot & Rambo Sts., Bridgeport, Pa.
Tube Reducing Corp., 520 Main Ave., Wallington, N.J.
Tubular Rivet & Stud Co., Weston Ave., Wollaston 70, Mass.
Turco Products, Inc., 6135 S Central Ave., Los Angeles 1, Calif.
Turner Halsey Co., 40 Worth St., New York 13, N.Y.
Turner & Seymour Mfg. Co., Lawton St., Torrington, Conn.
Twin City Die Castings Co., Talmage & 33rd Aves., SE, Minneapolis 14, Minn.
Twitchell, E. W. Inc. (Ad p 288)
2806 N 3rd St., Philadelphia 33, Pa.
Tyler Rubber Co., Andover, Mass.
Tyler, W.S. Co., 3615 Superior Ave., Cleveland 14, Ohio

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UBS Chemical Corp., 491 Main St., Cambridge 43, Mass.
Uddeholm Co. of America, Inc., 155 E 44th St., New York 17, N.Y.
Udylite Corp., 1651 Grand Blvd., Detroit 11, Mich.
Ulbrich Stainless Steels Corp. (Ad p 88)
Old Colony Rd., Wallingford, Conn.
Ullmann, Inc., 4305 N 127th St., Butler, Wis.
Uniform Tubes, Inc., Level & School Rds., Collegeville 2, Pa.
Union Asbestos & Rubber Co., 1111 W Perry St., Bloomington, Ill.
Union Carbide Corp., 30 E 42nd St., New York 17, N.Y.
Haynes Stellite Co. Div., 1020 W Park Ave., Kokomo, Ind.
Linde Co. Div., 30 E 42nd St., New York 17, N.Y.
National Carbon Co. (Ad p 299)
30 E 42nd St., New York 17, N.Y.
Silicones Div., 30 E 42nd St., New York 17, N.Y.
Union Carbide Metals Co. (Ad pp 144-145)
30 E 42nd St., New York 17, N.Y.
Union Carbide Plastics Co. Div., 30 E 42nd St., New York 17, N.Y.
Textile Fibers Dept., 100 E 42nd St., New York 17, N.Y.
Union Chemical Corp., 410 Frelinghuysen Ave., Newark 5, N.J.
Union Forging Co., 500 North St., Endicott, N.Y.
Union Iron Works, P.O. Box 2135, Spokane, Wash.
Union Paste Co., 1805 Hyde Park Ave., Hyde Park 36, Mass.
Union Screw & Mfg. Co., Box 25, Imperial, Pa.
Union Spring & Mfg. Co., 2nd Ave. & 8th St., New Kensington, Pa.
Union Steel Corp., Stanley Terrace, Union, N.J.
Union Tank Car Co., 228 N LaSalle, Chicago, Ill.
Unitcast Corp. (Ad p 392)
Water Works Dr., Toledo 9, Ohio
United Carbon Products Co., 1310 N Madison St., Bay City, Mich.
United Cork Cos., 15 Central Ave., Kearney, N.J.
United Forge Co., 277 Dubois, Detroit 7, Mich.
United International Research, Inc., 38-15 30th St., Long Island City 1, N.Y.
United Metal Products Corp., 8101 Lyndon Ave., Detroit 38, Mich.
United Rubber & Chemical Co., P.O. Box 1913, Charleston 27, W. Va.
United Screw & Bolt Corp., 2513 W Cullerton Ave., Chicago 8, Ill.
United Shoe Machinery Corp., 140 Federal St., Boston 7, Mass.
United Sintered Alloys, St. James, L.I., N.Y.
United Smelting & Aluminum Co., Inc., P.O. Box 1910, New Haven 9, Conn.
U.S. Bronze Powder Works, Inc., Rt. No. 202, Flemington, N.J.
U.S. Ceramic Tile Co., Sparta Mfg. Co., Dover, Ohio
U.S. Challenge & Challenge Co., 1441 N Kingsburg St., Chicago 22, Ill.
U.S. Extrusions Corp., 120 Old Broadway, Garden City Park, N.Y.
U.S. Flexible Tubing Co., Bartlett, Ill.
U.S. Gasket & Shim Co., 2743 2nd St., Cuyahoga Falls, Ohio
U.S. Gypsum Co., 300 W Adams St., Chicago 6, Ill.
U.S. Magnesium Co., Pleasant Valley, N.Y.
U.S. Metal Products Co., P.O. Box 1067, Erie, Pa.
U.S. Mica Co., Inc., 1525 Circle Ave., Forest Park, Ill.
U.S. Pipe and Foundry Co., 3300 1st Ave. N, Birmingham 3, Ala.
U.S. Plywood Corp., 55 W 44th St., New York 36, N.Y.
U.S. Polymeric Chemicals, Inc., Box 546, Stamford, Conn.
U. S. Reduction Co., Chicago Ave. & Melville St., East Chicago, Ind.
U. S. Rubber Co., 1230 Ave. of the Americas, New York 20, N.Y.
Footwear Div. (Ad p 243)
2638 Pulaski Rd., Chicago 39, Ill.
Kem-Blo Dept., Naugatuck, Conn.
Mechanical Goods Div., 4300 New Haven Ave., Fort Wayne, Ind.
Naugatuck Chemical Div., Elm St., Naugatuck, Conn.
Textile Div., 1230 Ave. of the Americas, New York 20, N.Y.
U. S. Smelting, Refining & Mining Co., 62 William St., New York, N.Y.
U.S. Steel Corp. (Ad pp 84-85)
525 William Penn Pl., Pittsburgh 30, Pa.
American Steel & Wire Div. (Ad pp 78-79)
Rockefeller Bldg., Cleveland 13, Ohio
Columbia-Geneva Steel Div., 120 Montgomery St., San Francisco 6, Calif.
National Tube Div., 525 William Penn Pl., Pittsburgh 30, Pa.
Tennessee Coal and Iron Div., P.O. Box 599, Fairfield, Ala.
United States Steel Supply Div., 208 S La Salle St., Chicago 4,
U. S. Stoneware Co., P.O. Box 350, Akron 9, Ohio
Alite Div., P.O. Box 119, Orrville, Ohio
Colonial Rubber Co. Div., 706 Oakwood St., Ravenna, Ohio
Conneaut Rubber & Plastics Co. Div., Commerce St., Conneaut, Ohio
U.S. Valve & Mfg. Co., 256 E Grand Ave., South San Francisco, Calif.
United Wire & Supply Corp., 1497 Elmwood Ave., Providence 7, R.I.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Unity Machine & Tool Corp., 2727 E Westmoreland St., Philadelphia 34, Pa.
Universal Castings Corp., 5821 W 66th St., Chicago 38, Ill.
Universal Converting Corp., 1125 County St., New Bedford, Mass.
Universal Unlimited, Inc., Pratt Oval, Glen Cove, N.Y.
Universal-Cyclops Steel Corp., Bridgeville, Pa.
Empire-Reeves Steel Div., Bridgeville, Pa.
University of Tennessee, Dept of Chemistry, University Sta., Knoxville 16, Tenn.
Uniworld Research Corp. of America, 9802 Euclid Ave., Cleveland 6, Ohio
Upson Co., Stevens St., Lockport, N.Y.
Urrite Plastics Fabricators, 4740-2 S Durfee Rd., Pico-Rivera, Calif.
Utica Drop Forge & Tool Co., 2409-15 Whitesboro St., Utica 4, N.Y.
Utica General Jobbing Foundry, Inc., 1801 Foundry St., Utica 3, N.Y.
Utica Radiator Corp., Dwyer Ave., Utica, N.Y.
Utility Mfg. Co., 2443 Boston Rd., North Wilbraham, Mass.
Utility Steel Foundry, 3320 E Slauson, Vernon, Calif.

V

Valley Iron Works, 81 E Water St., St Paul 7, Minn.
Valley Steel Casting Co., Foot of 11th St., Bay City, Mich.
Valley-National Corp., Clark St., Milldale, Conn.
Vanadium-Alloys Steel Co., Latrobe, Pa.
Anchor Drawn Steel Co., Latrobe, Pa.
Colonial Steel Div., Monaca, Pa.
Metal Forming Corp. Div., 1937 Sterling Ave., Elkart, Ind.
Vanamatic Co., 204 S Jefferson St., Delphos, Ohio
Van der Horst Corp., Olean, N.Y.
Van Dorn Iron Works Co., Colonial Plastics Div., 2685 E 79th St., Cleveland 4, Ohio
Van Huffell Tube Corp., Larchmont Ave., NE, Warren, Ohio
Van Pelt Corp., Service Steel Div., Box 532, Detroit 32, Mich.
Van Valkenburg, L.D. Co., Box 190, Holyoke, Mass.
Vanadium Corp. of America (Ad p 87)
420 Lexington Ave., New York 17, N.Y.
Varcum Chemical Corp., P.O. Box 476, Niagara Falls, N.Y.
Varflex Corp., 512 W Court St., Rome, N.Y.
Variety Stamping Corp., 12695 Elmwood Ave., Cleveland 11, Ohio
Vascoloy-Ramet Corp., 800 Market St., Waukegan, Ill.
Veeder-Root Inc., 70 Sargeant St., Hartford 2, Conn.
Vellumoid Co., 54 Rockdale St., Worcester 6, Mass.
Veremere, E.A. Inc., 11623 S Broadway, Los Angeles 61, Calif
Victor Equipment Co., 844 Folsom St., San Francisco 7, Calif.
Victor Mfg. & Gasket Co., 5750 W Roosevelt Rd., Chicago 50, Ill.
Victor Steel Products Corp., 1175 Leggett Ave., New York 59, N.Y.
Victory Plastics Co., 81 Apsley St., Hudson, Mass.
Viking Copper Tube Co., 16700 St. Clair Ave., Cleveland, Ohio
Viking Pump Co., George & Wyth Sts., Cedar Falls 1, Iowa
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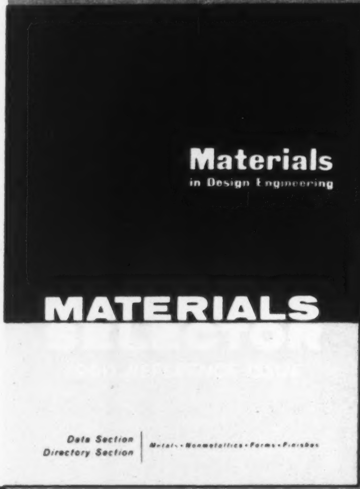

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for example —

Carbon steels
Alloy steels
Stainless steels
Tool steels
Heat resistant alloys
Gray, malleable, nodular irons

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NONFERROUS METALS

for example —

Aluminum
Copper, brass, bronze
Magnesium
Zinc, lead, tin
Nickel
Titanium
Zirconium
Low melting alloys
Noble metals
Rare metals
Cemented carbides

Editorial coverage in '58 — 285 pages

NONMETALLIC MATERIALS

for example —

Plastics
Rubbers
Silicones
Vulcanized fibres
Impregnated materials
Wood-base materials
Ceramics
Refractories
Glasses and fiberglass
Carbon and graphite
Industrial felts, fabrics and fibers
Leather
Paper-base materials

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FORMS & SHAPES

for example —

Sand castings
Die castings
Permanent mold castings
Precision castings
Centrifugal castings
Shell mold castings
Drop and press forgings
Stampings
Headed products
Weldments
Brazed assemblies
Metal powder parts
Extrusions
Spinnings
Wire and wire parts
Screw machine products
Drawn and roll formed parts
Tubing and tubular parts
Molded nonmetallics
Formed nonmetallics

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FINISHES & COATINGS

for example —

Plated coatings
Clad surfaces
Galvanized, tinned metals
Hard facings
Paints, synthetics, enamels
Anodized finishes
Phosphate coatings
Rustproofing
Chemical coloring
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